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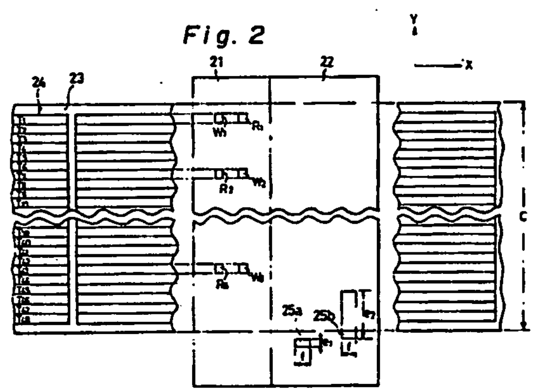
(54) Magnetic recording/reproducing apparatus.

(57) A magnetic recording/reproducing apparatus of serpentine system capable of recording/reproducing a large amount of high density data at high speed with a tracking control for precisely positioning a combination head includes a combination head having a magnetic head corresponding to a magnetic tape formed by a plurality of tracks arranged in parallel to one another in a direction in which the magnetic tape runs, and a light emitting unit disposed at a position confronting one side of the magnetic tape for emitting light in a widthwise direction of the magnetic tape. The appratus also includes a light receiving unit having a plurality of light receiving elements disposed at a position confronting the other side of the magnetic tape for receiving the light emitted from the light emitting unit such that the light receiving unit are so disposed that outputs from the light receiving elements have a predetermined relation which governs the feedback control at a time when the magnetic head moved to a predetermined track position, and a head operating unit capable of moving the combination head in the widthwise direction of the magnetic tape. The apparatus further has a slit plate formed integrally with the combination head and having openings whose number is the same as the number of a plurality of tracks confronting the magnetic head in the widthwise end portion and the the other end portion of the magnetic tape.

Fig. 2



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MAGNETIC RECORDING/REPRODUCING APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a multi-track magnetic recording/reproducing apparatus which uses a magnetic tape having a reduced width as a recording medium. More particularly, the present invention relates to a magnetic recording/reproducing apparatus capable of precisely recording/reproducing a large amount of data at high speed and the precise recording/reproducing being performed with a precise tracking control maintained.

2. Description of the Related Art

The inventors know that a magnetic recording/reproducing apparatus, except the one having a rotary head, used for an audio device has the same numbers of the tracks and the recording heads or the same numbers of the reproducing heads and the recording heads in pairs. The above-described term "the number of the tracks" means the total number of data tracks formed in parallel to the direction in which the tape runs. The magnetic recording/reproducing apparatus of the above described type includes a device for restricting the relative positions between the magnetic tape and the magnetic head. The restricting device has generally a guide post or the like, having a pair of flanges for guiding the two vertical ends of the magnetic tape so as to make it run toward the fixed magnetic head, is formed in a passage through which the magnetic tape runs. Thus, the vertical movement of the magnetic tape is restricted.

On the other hand, a multi-track magnetic recording/reproducing apparatus used for a backup storage of an information processing system, so-called "a cassette streamer", employs a recording/reproducing system known as "a serpentine system". A conventional serpentine system has a pair of a recording head for recording and a reproducing head for reproducing the contents when a magnetic tape is run in one direction and another pair of a recording head for recording and a reproducing head for reproducing th contents when the magnetic tape is run in the other direction so that it is capable of corresponding to a plurality of tracks. In this system, information is successively recorded or reproduced from tracks during th running of the magnetic tape in one direction or in the other direction instead of recording information on a plurality of tracks of the magnetic tape simultaneously. At the time of the above-described operation, the tracks are switched by moving the above-described two pairs of the recording heads and the reproducing heads, and the positioning of the magnetic tape to the position of a desired track is simultaneously performed. There is a known device for restricting the relative positions between the head and the magnetic tape as disclosed in Japanese Patent Laid-Open No. 62-183019 in which the positioning of the head is achieved in accordance with an open loop control method with a stepping motor provided in which the restricting flanges are used in addition to the above-described structure.

Recently, a combination head having a multi-heads has been developed in accordance with an advancement of a thin film magnetic head. Therefore, multi-track magnetic recording/reproducing apparatuses with further high density has been developed. The apparatus of the type described above is capable of recording information in a narrow track width, causing an allowable off track to be reduced. Therefore, in order to operate a precise tracking control, the device for restricting the relative positions between the tape and the head has an additional structure which followup-controls the magnetic head with respect to the waving movement of the magnetic head. The added structure is a head moving device for moving the magnetic head in the widthwise direction of a tape in addition to the above-described mechanism in which the flanges are provided for the purpose of restricting the vertical movement of the magnetic tape.

The apparatus of the type described above is exemplified by a fixed-head digital audio tape recorder which has the same numbers of the recording heads and the tracks or the same numbers of the reproducing heads each of which forms a pair with the above-described recording heads and the tracks. The apparatus of the type described above is arranged, as disclosed in the Trans. IECE Japan EA83-56, Trans. IECE Japan EA81-64 and the Sharp Engineering Report 1984-28, a servo-only track formed on the magnetic tape is traced by two parallel reproducing heads disposed in the widthwise direction of the tape so as to compare and followup-control the reproduction output therefrom for restricting the relativ positions between the magnetic head and the magnetic tape.

Another device for restricting the relative positions between the tape and the head has been disclosed in Japanese Patent Publication No. 63-64811 in which a structur for magnetically detect-

ing th relativ positions between an end portion of the magnetic tape and the magnetic head is provided for a magnetic recording/reproducing apparatus arranged to have the same number of the heads and the tracks.

However, the device for restricting the relative positions between the tape and the head has a guide post having flanges which restrict the vertical movement of the magnetic tape by contacting the vertical ends of the magnetic tape with the flanges of the guide post. Therefore, if a magnetic tape having a width which is larger than the distance between the upper flange and the lower flange is driven, the mechanical stresses act upon the two vertical ends of the magnetic tape and cause the two vertical ends of the magnetic tape to be damaged. Therefore, the restriction width in the above-described restricting device is limited to several tens of µm, because the end portions of the magnetic tape must be protected from the damage. Consequently, in a high density magnetic recording/reproducing apparatus in which the allowable offtrack is arranged in the range from ten and several µm to several tens of µm, the above-described structure in which the movement of the magnetic tape is restricted by the flanges or the like cannot correspond to the above-described allowable offtrack.

When a higher recording density is desired, the width of the track of the magnetic tape can be reduced by reducing the width of the track of the magnetic head. However, the reduction in the track pitch involves a certain limit since the integration of the thin film head is limited to a certain degree. Furthermore, an increase in the number of the heads causes the size of the circuit to be enlarged and the overall cost is thereby risen. Therefore, a high density magnetic recording/reproducing apparatus which is provided with the pitch of the tracks is several tens of µm and the several tens to hundreds of tracks cannot employ the same number of the heads and the tracks.

On the other hand, the multi-track magnetic recording/reproducing apparatus so-called a cassette streamer and employing the conventional serpentine system is arranged to record/reproduce information on the multiplicity of the tracks by moving the magnetic head in the widthwise direction of the magnetic tape. Therefore, the recording/reproducing can be operated by moving the magnetic head in several times even if the track pitch is reduced and the number of the tracks is increased. Therefore, th integrati n of th thin film head does not ncounter a problem.

Howev r, the track width necessarily becom s several tens of µm when th track pitch is made several tens of µm. Therefore, the allowable offtrack also becomes ten and several µm to several tens of µm. It leads a fact that the device for restricting the relative positions between the tape and the head, in which the restriction by means of the flanges or the like and the open loop control by using the stepping motor are performed, does not correspond to the above-described allowable offtrack.

It might therefore be considered feasible to employ a structure for overcoming the above-described problem in terms of the allowable offtrack, the structure being arranged such that the relative positions between the magnetic head and the magnetic tape is detected by a sensor and the head operating device is feed-back controlled by a detection signal so that the magnetic head is tracking-controlled.

However, if the above-described tracking control of several µm is desired to be achieved, a mechanism for supporting the magnetic head, a power source for the magnetic head, a mechanism for transmitting power to the magnetic head, and a sensor for detecting the relative positions between the magnetic tape and the magnetic head must be constituted precisely. However, the conventional head operating device has a complicated structure and a large dead zone since it includes the power source utilizing a rotary motor such as the stepping motor, a mechanism for converting the rotational motion of the rotary motor into a linear motion, a bearing supporting mechanism and the like. Therefore, a desired control accuracy cannot be obtained. Furthermore, since a mechanism for supporting the magnetic head by means of parallel leaf springs is employed in the conventional structure, a feedback control with an excellent gain cannot be obtained easily due to an influence of the secondary resonance. The secondary resonance takes place because the magnetic head is secured to either of the leaf springs or because the mechanism for supporting the magnetic head is connected to the above-described mechanism for converting the rotational motion of the power source for the magnetic head into the linear motion.

Furthermore, if the tracking control by means of the servo track of the type employed in the above-described fixed-head digital audio tape recorder is operated in accordance with the serpentine method, a multi-servo tracks must be provided and problems in terms of a recording density on the servo track arise. Therefore, even if the method of this type is employed, the high density recording cann t be btaied satisfactorily.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a magnetic recording/reproducing apparatus of a

serpentine system capable of recording/reproducing a large am unt of high density data at high speed with a tracking control for precisely positioning a combination head. The apparatus of the present invention is capable of recording/reproducing the data without providing flanges for restricting the relative positions between the magnetic tape and the magnetic head and without a servo track on the magnetic tape.

The object of the invention can be achieved by a magnetic recording/reproducing apparatus of serpentine system capable of recording/reproducing a large amount of high density data at high speed with a tracking control for precisely positioning a combination head includes a combination head having a magnetic head corresponding to a magnetic tape formed by a plurality of tracks arranged in parallel to one another in a direction in which the magnetic tape runs, a light emitting unit disposed at a position confronting one side of the magnetic tape for emitting light in a widthwise direction of the magnetic tape, a light receiving unit having a plurality of light receiving elements disposed at a position confronting the other side of the magnetic tape for receiving the light emitted from the light emitting unit such that the light receiving unit are so disposed that outputs from the light receiving elements have a predetermined relation which governs the feedback control at a time when the magnetic head moved to a predetermined track position, and a head operating unit capable of moving the combination head in the widthwise direction of the magnetic tape.

Preferably, the combination head includes the light receiving elements whose number is the same as the number of the plurality of the tracks at end portion and at the other end portion in the widthwise direction of the magnetic tape, the light receiving elements disposed at the end portion are arranged in parallel with light receiving elements disposed at the other portion in a pair correspond to a predetermined track of the magnetic tape.

Furthermore, the light emitting unit is disposed at a position which confronts the light receiving elements via two end portions of the magnetic tape.

The light receiving unit may preferably is formed integrally with the combination head and has a first light receiving element of a light receiving area Sa_1 and a second light receiving element of a light receiving area Sb_1 with a relation of $Sb_1 \geq n \times Sa_1$ where n represents a positive integer, and th predetermined relation is $Eb_1 = m \times Ea_1$ where m represents a positive integer satisfying $1 \leq m \leq n$ and differs in accordance with each of relative positions between the magnetic head and the plurality of tracks in a movable range of the magnetic head.

More preferably, the light receiving unit is form d integrally on the combination head and has n pieces of light receiving elements f Da_1 to Da_n with the same width in a direction in which the magnetic tape runs, where n represents a positive integer satisfying the relation of $n \geq 3$, a direction of the widthwise end portion of the magnetic tape is arranged to be - Y direction and a direction of the other end portion of the magnetic tape is arranged to be + Y direction, the light receiving elements Da_1 to Da_n are disposed in the - Y direction as well as in a direction in which the magnetic tape runs, the - Y directional end portion of the light receiving element Da_1 is positioned in the - Y direction by the largest degree among the light receiving elements of Da_1 to Da_n, a - Y directional end portion of the light receiving element Da_n is disposed at the n-th order in the - Y direction when the light receiving element Da_1 is arranged as the first light receiving element, and assuming that i represents a positive integer satisfying the relationship $1 \leq i \leq n - 1$, a pitch between a - Y directional end portion of the i-th light receiving device Dai and a - Y directional end portion of the i + 1-th light receiving device Da_{i+1} is di, and the light receiving devices Da_1 to Da_n hold relative positions $di = d$ when $i \leq 2$ and $di = (i - 2) \times d$ when $3 \leq i \leq n - i$, and the light receiving elements Da_1 to Da_n are disposed such that an output difference between two of the light receiving elements Da_1 to Da_n due to light emitted from the light emitting unit becomes an output from a light receiving element at a time when the magnetic tape moved to an optional track position with respect to the - Y directional end, and a relation among outputs from the three light receiving elements differes in accordance with each of relative positions between the magnetic tape and the combination head.

The light emitting unit may preferably be disposed at a position confronting the light receiving devices Da_1 to Da_n with the - Y directional end of the magnetic tape disposed therebetween, and the predetermined relation is formed among the three light receiving elements.

The object of the invention can be also achieved by a magnetic recording/reproducing apparatus of serpentine system capable of recording/reproducing a large amount of high density data at high speed with a tracking control for precisely positioning a combination head includes a combination head having a magnetic head corresponding to a magnetic tape formed by a plurality of tracks arranged in parallel to one another in a direction in which the magnetic tape runs, a slit formed integrally with the combination head and having openings whose number is the same as the number of a plurality of tracks confronting the

magnetic head in the widthwise end portion and the other end portion of the magnetic tape, a light emitting unit disposed in a position confronting one side of the magnetic tape and capable of emitting light through an end portion in a widthwise direction of the magnetic tape, a light receiving unit having a plurality of light receiving elements disposed at a position confronting the other side of the magnetic tape for receiving the light emitted from the light emitting unit such that the light receiving unit are so disposed that outputs from the light receiving elements have a predetermined relation which governs the feedback control at a time when the magnetic head moved to a predetermined track position, and a head operating unit capable of moving the combination head in the widthwise direction of the magnetic tape.

Preferably, the light receiving unit is formed independently from the combination head and the light receiving elements are disposed at a position which confronts the opening of the slit plate formed at the end portion, and the openings are placed in parallel with the opening at the other end portion in the widthwise direction of the magnetic tape to one another with the openings in a pair correspond to a predetermined track of the magnetic tape.

The slit plate may preferably has openings at the end portion and the openings at the other end portion so disposed that outputs from the light receiving elements due to light emitted from the light emitting unit via a pair of opening corresponding to the track and to the two widthwise end portions of the magnetic tape establish the predetermined relationship.

Preferably, the light emitting unit is disposed at a position confronting the light receiving element via the two widthwise end portions of the magnetic tape and the slit plate.

Furthermore, the combination head is supported between free ends of two parallel leaf springs, one end-portion of one of the parallel leaf springs being secured and the other one end-portion thereof formed the free end.

The head operating unit may include a voice coil type linear motor, and a magnetic circuit of the voice coil type linear motor is closed in a direction of the combination head and in a direction of the magnetic tape.

Preferably, the apparatus further includes a movable portion connected to the coil and disposed between the free ends, the movable portion having the combination head and a supporting member for supporting the combination head and capable of synchronizing with a movement of the a coil of the voice coil type linear motor so as to make power of the voice coil type linear motor pass through a portion in the vicinity of the center f gravity of the movable portion.

The apparatus may further include detection unit for optically detecting the relative position between the combination head and either on or both of widthwise directional edges of the magnetic tape, and the detecting unit outputs a signal which controls a switching operation of the tracks and the relative position between the magnetic tape and the combination head.

Preferably, the combination head is disposed at a position confronting the side of the magnetic tape and has a first opening of an opening Sa_2 and a second opening of an opening area Sb_2 which are integrally formed with the combination head.

The slit plate may be disposed the other side in which the opening area Sa_2 and the opening Sb_2 holds the relationship $Sb_2 \geq n \times Sa_2$, where n represents a positive integer, and the light receiving unit formed independently from the combination head is disposed at a position confronting the other side of the magnetic tape and has a first light receiving element corresponding to the first opening and a second light receiving element corresponding to the second opening.

The first opening and the second opening are preferably disposed to the widthwise end portion of the magnetic tape, and an output Ea_2 from the first light receiving element and an output Eb_2 from the second light receiving element holds the relationship $Eb_2 = m \times Ea_2$ where m represents a positive integer satisfying the relation of $1 \leq m \leq n$ and differing in accordance with each of relative positions between the magnetic head and the plurality of tracks in a range in which the magnetic head can move.

Furthermore, the emitting unit is disposed at a position confronting the first light receiving element and the second light receiving element with the slit plate and the widthwise end portion of the magnetic tape disposed therebetween, and a feedback control of the apparatus is controlled by the first and second openings having a relation of $Eb_2 = m \times Ea_2$ in accordance with the output Ea_2 and the output Eb_2.

More preferably, the slit plate has n pieces of opening A_1 to A_n having the same width in a direction in which the magnetic tape runs on the other side of the magnetic tape where n represents a positive integer satisfying the relation of $n \geq 3$, and n pieces of light receiving elements Db_1 to Db_n respectively corresponding to the openings A_1 to A_n are independently formed with respect to the c mbination head on the one side of the magnetic tape, a directin of th widthwise end portion of the magnetic tape is arranged to be - Y direction and a direction of the other end portion of the magnetic tape is arranged to be + Y direction, the opening A_1 to A_n are disposed in a - Y direction and in the direction in which the magnetic tape runs when a

direction of the widthwise end portion of the magnetic tape is arranged to be - Y direction and a direction of the other end portion of the magnetic tape is arranged to be + Y direction, a - Y directional end portion of the opening A_1 is positioned in the - Y direction by the largest degree among the opening A_1 to A_n, an - Y directional end portion of the openings A_n is disposed at the n-th order in the - Y direction when the opening A_1 is selected as the first opening, assuming that i represents a positive integer satisfying the relation of $1 \leq i \leq n - 1$, a pitch between a - Y directional end portion of the i-th opening A_1 and a - Y directional end portion of the - + 1-th opening $A_1 + 1$ is di, the openings A_1 to A_n hold the relative positions di = d when $i \leq 2$ and di = (i - 2) × d when $3 \leq i \leq n - 1$, the openings A_1 to A_n are disposed such that an output difference between two of the light receiving elements Db_1 to Db_n due to light emitted from the light emitting unit becomes an output from a light receiving element at a time when the magnetic tape moved to an optional track position with respect to the - Y directional end, and a relation among output from the three light receiving elements differs in according with each of relative positions between the magnetic tape and the combination head.

Preferably, the light emitting unit is disposed at a position confronting the light receiving devices Db_1 to Db_n with the - Y directional end of the magnetic tape disposed therebetween, and the S predetermined relation is an output relation among the three light receiving elements due to light emitted from the light emitting unit via the - Y directional end of the magnetic tape and the openings A_1 to A_n.

According to a magnetic recording/reproducing apparatus according to the present invention, when data on a predetermined track of a magnetic tape is reproduced, a combination head is operated by a head operating unit so that a predetermined magnetic head of the combination head is moved to a position of the predetermined track of the magnetic tape. In accordance with this movement, a first and a second light-receiving device integrally provided with the combination head are simultaneously moved. As a result of the above-described movement, the light receiving surface of the second light-receiving device is shielded at an end portion of the magnetic tape, causing the quantity of received light emitted from light emitting unit to be changed. Accordingly to the present invention, a light-receiving area Sa_1 of the first light-receiving device and a light-receiving area Sb_1 of the second light-receiving device hold a relationship $Sb_1 \geq n \times Sa_1$ (where n represents a positive integer) . The first light-receiving -device and the second light-receiving device are positioned such that an output level Ea_1 from the first light-receiving device due to incident light from the light emitting unit and an output level Eb_1 from the second light-receiving device due to the incident light from the light emitting unit hold a relationship $Eb_1 = m \times Ea_1$ ($1 \leq m \leq n$, where m represents a positive integer) when the magnetic track moved to an optional track position. Furthermore, the above-described numeral m corresponds to each of the relative positions between a predetermined magnetic head of the combination head and a plurality of the tracks positioned in the range in which the magnetic head can be moved, the numeral m being arranged to become different in accordance with each of the above-described relative positions. Therefore, the head operating unit operates a feedback control by calculating the output levels Ea_1 and Eb_1 from the corresponding the first and the second light-receiving devices so as to make the output levels Ea_1 and Eb_1 establish a relationship $Eb_1 = m \times Ea_1$ which includes the numeral m corresponding to the relative positions between the above-described magnetic head and the tracks. As a result, the relative positions between the magnetic head and the tracks are followup-controlled so that the relative positions are maintained as desired.

Accordingly a followup track control of about several µm and a track switching operation of about hundreds of µm to several µm can be operated by a head operating unit. Therefore, a large amount of data can be precisely magnet-recorded/reproduced from on several tens to hundreds of tracks whose pitch is several tens of µm.

The accuracy of positioning the first and the second light-receiving devices can be achieved satisfactorily since the above-described two devices are manufactured by a semoconductor technology, and an accurate position sensor can be manufactured.

In the magnetic recording/reproducing apparatus according to the present invention, when data on the predetermined track of a magnetic tape is reproduced, the combination head is operated so that a predetermined magnetic head is moved to a predetermined track position. In accordance with this movement, a slit plate integrally formed with the combination head is simultaneously moved. As a result of this movement, the light receiving surface of the second light-receiving device is shielded in the periphery of the second opening formed in the slip plate, causing the quantity of received light emitted from light emitting unit to be changed. According to th present invention, a light-receiving area Sa_2 of the first opeing form d in the slit plate and a light-receiving area Sb_2 of the second opening hold a relationship $Sb_2 \geq n \times Sa_2$ (where n represents a positive integer). The first light-receiv-

ing device corresponding to th first opening and the second light-receiving device corresponding to the second op ning are formed independently from the combination head on the opposite side of the slit plate confronting the magnetic tape. Furthermore, the first opening and the second opening are positioned such that an output level Ea_2 from the first light-receiving device due to incident light from the light emitting unit and an output level Eb_2 from the second light-receiving device due to the incident light from the light emitting unit hold a relationship $Eb_2 = m \times Ea_2$ ($1 \leq m \leq n$, where m represents a positive integer) when the magnetic track moved to an optional track position. Furthermore, the above-described numeral m corresponds to each of the relative positions between a predetermined magnetic head of the combination head and a plurality of the tracks positioned in the range in which the magnetic head can be moved, the numeral m being arranged to become different in accordance with each of the above-described relative positions. Therefore, the head operating unit performs a feedback control by calculating the output levels Ea_2 and Eb_2 from the corresponding first and the second light-receiving devices so as to make the output levels Ea_2 and Eb_2 establish a relationship $Eb_2 = m \times Ea_2$ which includes the numeral m corresponding to the relative positions between the above-described magnetic head and the tracks. As a result, the relative positions between the magnetic head and the tracks are followup-controlled so that the relative positions between them is maintained as desired.

Accordingly, a large amount of data can be precisely magnet-recorded/reproduced similarly to the above-described magnetic recording/reproducing apparatus.

The accuracy at the time of positioning the first and the second openings in the slit plate can be achieved satisfactorily since the above-described two openings are manufactured bye an etching technology, and an accurate position sensor can be manufactured.

According to a magnetic recordsing/reproducing apparatus according to the present invention, when data on a predetermined track of a magnetic tape is reproduced, a combination head is operated by a head operating unit so that a predetermined magnetic head of the combination head is moved to a position of the predetermined track of the magnetic tape. In accordance with this movement, n (where $n \geq 3$ and n represents a positive integer) pieces of light-receiving devices Da_1 to Da_n integrally provided with the combination head are simultaneously moved. As a result of the above-described movement, the light receiving surface of all of the light receiving devices Da_1 to Da_n or a predetermined light receiving device of the same is shielded at the end portion in the Y-direction of the magnetic tap , that is, at a widthwise end of the magnetic tape, causing the quantity of received light emitted from light emitting unit to be changed.

According to the present invention, the end portion in the - Y direction of the above-described light receiving device Da_1 is positioned at the most - Y directional end among the light receiving devices Da_1 to Da_n. Furthermore, the light receiving device Da_n is the n-th light receiving device in the - Y direction when counted with letting the light receiving device Da_1 be the first light receiving device. Assuming that the pitch between the - Y directional end of the light receiving device Da_i ($1 \leq i \leq n-1$, where i represents a positive integer) and that of the light receiving device Da_{i+1} is di and the width of each of the tracks of the magnetic tape is d, the light receiving devices Da_1 to Da_n has the positional relationship:

$di = d$ when $i \leq 2$

$di = (i - 2) \times d$ when $3 \leq i \leq n-1$

The light receiving devices Da_1 to Da_n are positioned so as to make the difference in the output between optional two light receiving devices of the light receiving devices Da_1 to Da_n due to incident light from light emitting unit becomes the same as another optional light receiving device when the magnetic head moved to an optional track position with respect to the - Y directional end of the magnetic tape. Furthermore, the relationship among the outputs from the above-described three light receiving devices is arranged to be different in accordance with the relative positions between the magnetic tape and the combination head. Therefore, the head operating unit operates a feedback control by calculating the outputs from the three light receiving devices corresponding to the relative positions between the magnetic tape and the combination head so as to make the difference in the output between the predetermined two light receiving devices the same as the other light receiving device. As a result, the relative positions between the magnetic head and the tracks are followup-controlled so that the relative positions between them is maintained as desired.

According to a magnetic recording/reproducing apparatus according to the present invention, when data on a predetermined track of a magnetic tape is reproduced, a combination head is operated so that a predetermined magnetic head is moved to a position of the predetermined track. In accordance with this movement, a slit plate integrally provided with the combination head is simultaneously moved. As a result of the above-described movement, the light receiving surface of all of the light receiving devices Da_1 to Da_n or a predet rmined light receiving device of the same is shielded at a

periphery of each of openings A_1 to A_n, causing the quantity of received light emitted from light emitting unit to be changed.

According to the present invention, th end portion in the - Y direction of the above-described opening A_1 is positioned at the most - Y directional end among the openings Da_1 to Da_n. Furthermore, opening A_n is the n-th light receiving device in the - Y direction when counted with letting the opening A_1 be the first opening. Assuming that the pitch between the - Y directional end of the opening A_i ($1 \leq i \leq n-1$, where i represents a positive integer) and that of the opening A_{i+1} is di and the width of each of the tracks of the magnetic tape is d, openings A_1 to A_n has the positional relationship:

$di = d$ when $i \leq 2$

$di = (i - 2) \times d$ when $3 \leq i \leq n-1$

The openings A_1 to A_n are positioned so that the difference in the output between optional two light receiving devices of the light receiving devices Da_1 to Da_n due to incident light from light emitting unit becomes the same as another optional light receiving device when the magnetic head moved to an optional track position with respect to the - Y directional end of the magnetic tape. Furthermore, the relationship among the outputs from the above-described three light receiving devices is arranged to be different in accordance with the relative positions between the magnetic tape and the combination head. Therefore, the head operating unit operates a feedback control by calculating the outputs from the three light receiving devices corresponding to the relative positions between the magnetic tape and the combination head so as to make the difference in the output between the predetermined two light receiving devices the same as the other light receiving device. As a result, the relative positions between the magnetic head and the tracks are followup-controlled so that the relative positions between them is maintained as desired.

The accuracy of positioning the openings A_1 to A_n in the slit plate can be achieved satisfactorily since they are manufactured by an etching technology, and an accurate position sensor can be manufactured.

According to a magnetic recording/reproducing apparatus according to the present invention, when data on a predetermined track of a magnetic tape is reproduced, a combination head is operated by head operating unit so that a predetermined magnetic head of the combination head is moved to a position of the predetermined track of the magnetic tape. In accordance with this movement, a plurality of light receiving devices integrally provided with the combination head are simultaneously moved. As a result of the above-described movement, the light receiving surface of a light receiving device group at an end portion corresponding to th above-described predetermined track and a pair of light receiving devices at another end of the same is shielded by the two widthwise ends of the magnetic tape, causing the quantity of received light to be changed.

According to the present invention, a correspondent relationship is established between the light receiving devices of the light receiving device group at the one end and the light receiving devices of the light receiving device group at the other end. Furthermore, correspondent relationships are established between a pair of the corresponding light receiving devices and a predetermined track. Furthermore, the light receiving devices of the light receiving device group at the one end and the light receiving devices of the light receiving device group at the other end are positioned so as to make the output from each of the pair of the light receiving devices corresponding to the track has a certain relationship when the magnetic track moved to an optional track position. Therefore, the head operating unit operate a feedback control such that the output from each of the pair of the light receiving devices corresponding to the track due to incident light from light emitting unit via the two widthwise end portions of the magnetic tape has a certain relationship when the magnetic head moved to an optional track position. As a result, the relative positions between the magnetic head and the tracks are followup-controlled so that the relative positions between them is maintained as desired.

The accuracy at the time of positioning the light receiving devices can be achieved satisfactorily since they are manufactured by a semiconductor technology, and an accurate position sensor can be manufactured.

According to a magnetic recording/reproducing apparatus according to the present invention, when data on a predetermined track of a magnetic tape is reproduced, a combination head is operated so that a predetermined magnetic head is moved to a position of the predetermined track. In accordance with this movement, a slit plate integrally provided with the combination head is simultaneously moved. As a result of the above-described movement, a plurality of openings formed in the slit plate are also and simultaneously moved. Therefore, light is made incident through the opening group at an end portion which corresponds to the predetermined track and a pair of openings of the opening groups at another end upon the light receiving devices which correspond to these openings.

According to the present invention, a correspondent relationship is established between the openings at the end portion and those at the other end portion. Furthermore, correspondent relation-

ships are established between a pair f the corresponding openings and a predet rmined track. Furthermore, the openings of the opening group at the one end and the openings of the opening group at the other end are positioned so as to establish a certain relationship when the magnetic head moved to an optional track position, the relationship being the relationship between the outputs from the pair of the light receiving devices due to light made incident via the pair of openings corresponding to the track and the two widthwise end portions of the tape. Therefore, the head operating unit operates a feedback control such that the output from each of the pair of the light receiving devices corresponding to the above-described two openings due to incident light from light emitting unit via the two widthwise end portions of the magnetic tape has a certain relationship when the magnetic head of the combination head moved to an optional track position. As a result, the positional relationship between the magnetic head and the tracks are followup-controlled so that the positional relationship between them is maintained as desired.

The accuracy at the time of positioning the plurality of openings in the slit plate can be achieved satisfactorily since they are manufactured by an etching technology, and an accurate position sensor can be manufactured.

When the magnetic tape is allowed to run in a direction, a plurality of recording heads capable of recording data on the magnetic tape act to have data recorded on a plurality of tracks of the magnetic tape. Then, the magnetic tape is allowed to run in another direction, a plurality of recording heads capable of recording data on the magnetic tape act to have data recorded on another plurality of tracks of the magnetic tape.

Then, the combination head is moved in the widthwise direction of the magnetic tape by a distance of an integral multiple of the track pitch so as to cause the combination head to similarly perform the recording operation. Then, the above-described operation is repeated. The reproduction operation is arranged to be operated similarly to the recording operation.

According to the present invention, a voice coil type linear motor is used as the head operating unit. Therefore, the combination head can be operated without encountering problems in terms of a dead zone and of a frictional load. A servo control can be operated precisely with a satisfactory response achieved. Furthermore, the power of the voice coil type linear motor is arranged to be transmitted in the vicinity of the center of gravity of a movable portion which has a support member disposed between two free ends of two parallel leaf springs whose end portions are secured and the other end portions form free ends, and the combination head. Therefor , th influence of the secondary resonance can be reduced and the precision of the above-d scribed servo control can be improved.

Furthermore, the leakage flux from the voice coil type linear motor influencing the combination head and the magnetic tape can be reduced by closing a magnetic circuit of the voice coil type linear motor in the direction to the combination head and the magnetic tape.

In addition, since the relative positions between the combination head and the tape edge can be optically detected and it is feed-backed to the head operating unit by a signal from the sensor, the combination head can be precisely positioned. Therefore, the necessity of recording the servo track for detecting the relative positions between the combination head and the magnetic tape on the magnetic recording medium can be eliminated.

That is, a combination head having recording heads and reproducing head each of whose number is smaller than the number of the tracks on the magnetic tape can be precisely positioned. As a result, the recording/reproducing large amount of high density data can be recorded/reproduced at high speed in accordance with the serpentine method.

Since the combination head is supported between free ends of two parallel leaf springs whose end portions are secured and the other end portions form free ends, the operation of the combination head can be servo-controlled with an influence of the secondary resonance of the supporting mechanism for the combination head eliminated. Furthermore, the use of the voice coil type linear motor as the head operating unit will cause a servo control to be achieved with the dead zone and the friction load satisfactorily eliminated. Furthermore, the voice coil type linear motor arranged to operate the portion in the vicinity of the movable portion including the combination head will improve the above-described effect.

Furthermore, since the relative positions between the combination head and the tape edge can be optically detected and it is feed-backed to the head operating unit by means of a sensor signal, the combination head can be precisely positioned.

Further objects and advantages of the present invention will be apparent from the following description of the preferred embodiments of the invention as illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic front elevational view of the magnetic tape and the combination head for a

magnetic recording/reproducing apparatus according to the pr sent invention:

Fig. 2 is a front levational view which illustrates the relative positions among a magnetic tape, a combination head and a light receiving device;

Fig. 3a is a schematic plan view which illustrates the relative positions among the magnetic tape, the combination head and the light-receiving device;

Fig. 3b is a front elevational view which illustrates the relative positions among the magnetic tape, the combination head and the light-receiving device;

Fig. 4 is a front elevational view which illustrates the relative positions among the magnetic tape, the light receiving device of the combination head, the reference opening and an opening for detecting the positional relationship;

Fig. 5a is a schematic plan view which illustrates the relative positions among the magnetic tape, the combination head, a light-receiving device and a slit plate;

Fig. 5b is a front elevational view which illustrates the relative positions among the magnetic tape, the combination head, a light-receiving device and a slit plate;

Fig. 6 is a front elevational view which illustrates the relative positions among the magnetic tape, the combination head and the light receiving device;

Fig. 7a is a schematic plan view which illustrates the relative positions among the magnetic tape, the combination head and the light-receiving device;

Fig. 7b is a front elevational view which illustrates the relative positions among the magnetic tape, the combination head and the light-receiving device;

Fig. 8 is a front elevational view which illustrates the relative positions among the magnetic tape, the combination head, the light receiving device and openings formed in the slit plate;

Fig. 9a is a schematic plan view which illustrates the relative positions among the magnetic tape, the combination head, the light-receiving device holding member and the slit plate;

Fig. 9b is a front elevational view which illustrates the relative positions among the magnetic tape, the combination head, the light-receiving device holding member and the slit plate;

Fig. 10 is a front elevational view which illustrates the relative positions among the magnetic tape, the combination head and the light receiving device;

Fig. 11a is a schematic plan view which illustrates the relative positions among the magnetic tape, the combination head and the light-receiving device holding member;

Fig. 11b is a front elevational view which illustrates the relative positions among the magnetic tape, the combination head and the light-receiving device holding member;

Fig. 12 is a front elevational view which illustrates the relative positions among the magnetic tape, the combination head, the light-receiving device and openings formed in the slit plate;

Fig. 13a is a schematic plan view which illustrates the relative positions among the magnetic tape, the combination head, the light-receiving device holding member and the slit plate;

Fig. 13b is a front elevational view which illustrates the relative positions among the magnetic tape, the combination head, the light-receiving device holding member and the slit plate;

Fig. 14 is a perspective view which illustrates the magnetic tape in non-loaded state;

Fig. 15 is a perspective view which illustrates the magnetic tape in loaded state;

Fig. 16 illustrates the structure of a tracking control;

Fig. 17 illustrates the transfer function of the spring system of the parallel leaf spring supporting structure shown in Figs. 14 and 15; and

Fig. 18 illustrates the transfer function of the spring system when the combination head and the holder are not disposed between the parallel leaf springs with the axis of abscissa representing frequencies and the axis of ordinate representing gains.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A first embodiment of the present invention will now be described with reference to Figs. 1 to 3.

A magnetic recording/reproducing apparatus according to the present invention is to record and reproduce data in accordance with a serpentine method in which magnetic heads whose number is smaller than the number of the tracks of the magnetic tape used. First, the serpentine method which is used for the recording/reproducing apparatus according to the present invention will be described with reference to Fig. 1. Referring to Fig. 1, it is assumed that the direction in which a magnetic tape 11 runs is X and that the widthwise direction of the magnetic tape 11 is Y. A track group 12 is formed on the magnetic tape 11, the track group 12 having 16 tracks T_1 to T_{16} in the direction Y at the same pitch a. A combination head 13 having four recording heads W_1 to W_4 and reproducing heads R_1 to R_4 which are integrally formed and disposed so as to correspond to the above-described track group 12. The recording heads W_1 to W_4 are in parallel provided in the direction Y at the

same pitch b (b = 4a), while the reproducing heads R_1 to R_4 are disposed in parallel in direction X or - X in such a manner that they form pairs with the corresponding recording heads W_1 to W_4. The recording heads W_1 to W_4 and the reproducing heads R_1 to R_4 which form the pairs are alternately disposed in the direction Y.

When data is recorded or reproduced, the above-described combination head 13 is first moved to a position shown in Fig. 1. That is, it is moved to a position so as to make the center of the recording head W_1 and that of the reproducing head R_1 coincide with the center of the track T_1, the center of the recording head W_2 and that of the reproducing head R_2 coincide with the center of the track T_5, the center of the recording head W_3 and that of the reproducing head R_3 coincide with the center of the track T_9, and the center of the recording head W_4 and that of the reproducing head R_4 coincide with the center of the track T_{13}. Then, while maintaining the established relative positions, the magnetic tape 11 is allowed to run in the direction X when data is recorded so that data is simultaneously recorded on the tracks T_1 and T_9 by using the recording head W_1 and W_3. When the recording to the tape-end has been completed, the magnetic tape 11 is allowed to run in the - X direction so that data is simultaneously recorded on the tracks T_5 and T_{13} by using the recording heads W_2 and W_4. After the recording to the tape-end has been completed, the combination head 13 is moved in the - Y direction by a distance a so that the center of the recording head W_1 and that of the reproducing head R_1 coincide with the center of the track T_2. While the established relative positions maintained, the magnetic tape 11 is again allowed to run in the direction X so that data is recorded on the tracks T_2 and T_{10} by using the recording heads W_1 and W_3. After recording to the tape-end has been completed, the magnetic tape 11 is then allowed to run in the direction - X so that data is recorded on the tracks T_6 and T_{14} by using the recording heads W_2 and W_4. Similarly, data is recorded on all of the tracks T_1 to T_{16}. According to this embodiment, since the number of the reproducing heads and the number of the recording heads are respectively arranged to be four with respect to the 16 tracks, the relative positions between the magnetic tape 11 and the combination head 13 become four positions.

Now, a tracking control device of the magnetic recording/reproducing apparatus according to the present invention will be described with reference to Figs. 2 and 3.

As shown in Figs. 2, 3a and 3b, the magnetic recording/reproducing apparatus includes the combination head 21 having a light-receiving device holding member 22 formed integrally with the combination head 21.

A magnetic tape 23 has a track group 24 constituted by th 48 tracks T_1 to T_{48} formed in the direction Y at the same pitch as shown in Fig. 2. According to this embodiment, width C of the magnetic tape 23 is arranged to be 1/4 inch and the track pitch is arranged to be 120 µm.

The combination head 21 includes 8 recording heads W_1 to W_8 and reproducing heads R_1 to R_8 which are integrally formed with the combination head 21. The recording heads W_1 to W_8 are disposed in the direction Y at a pitch of 720 µm, while the reproducing heads R_1 to R_8 are disposed in the direction X or - X with forming pairs with the corresponding recording heads W_1 to W_8. The recording heads W_1 to W_8 and the reproducing heads R_1 to R_8 which form pairs are alternately disposed in the direction Y. When the magnetic tape 23 is allowed to run in the direction X, the four recording heads W_1, W_3, W_5 and W_7 of the combination head 21 perform the recording, while the magnetic tape 23 is allowed to run in the direction - X, the four recording heads W_2, W_4, W_6 and W_8 perform the recording. Furthermore, whenever the magnetic tape 23 reciprocates once, the combination head 21 is moved in the direction - Y so that the combination head 21 is positioned at 6 relative positions with respect to the magnetic tape 23. As a result, all of the 48 tracks T_1 to T_{48} area subjected to the data recording/reproducing.

Furthermore, the light-receiving device holding member 22 has a reference outputting light receiving device 25a serving as a first light receiving device and a light receiving device 25b for detecting the relative position and serving as a second light receiving device are formed at positions corresponding to the - Y directional end portion of the magnetic tape 23. The light receiving devices 25a and 25b can be moved in accordance with the movement of the combination head 21 in the ± Y directions since the light-receiving device holding member 22 is integrally formed with the combination head 21. The light receiving surface of the light receiving device 25a is arranged such that its Y directional width e1 is 120 µm which is the same width as that of the tracks T_1 to T_{48} while its X directional width is f with which a sufficient output level can be obtained. The light receiving device 25b is formed near the light receiving device 25a and the light receiving device 25b has a light receiving surface whose X directional width is arranged to be f and whose Y directional width e_2 is arranged be a proper value holding the relationship $e_2 \geq 720$ µm. The output level for a unit area of the two light receiving devices 25a and 25b are arranged to be the same. The reference-outputting light receiving device 25a is positioned such that it is not concealed by the magnetic tape 23. The light

receiving device 25b for detecting the relative positions are provided such that it - Y directional end appears from the - Y directional end of the magnetic tape 23 when the recording head W_1 and the reproducing head R_1 are at the track position T_1. Furthermore, it is structured such that its light receiving area appearing from the magnetic tape 23 becomes enlarged in accordance with the movement of the combination head 21 in the direction - Y. When the combination head 21 moved to each of the relative positions with respect to the magnetic tape 23, output Ea_1 from the light receiving device 25a and output Eb_1 from the light receiving device 25b hold the following relationship:

$Eb_1 = m \times Ea_1$ ($1 \leq m$, where m represents a positive integer)

The above-described numeral m represents the each of the relative positions between the reproducing head R_1 of the combination head 21 and the plurality of tracks T_1 to T_6 positioned in a range in which the reproducing head R_1 can move, the numeral m can be a different value in accordance with each of the relative positions. That is, according to this embodiment, for example, when the recording head W_1 moved to the positions of the tracks T_1, T_2, T_3, T_4, T_5 and T_6, the each of the following relationships is established: $Eb_1 = Ea_1$, $Eb_1 = 2Ea_1$, $Eb_1 = 3Ea_1$, $Eb_1 = 4Ea_1$, $Eb_1 = 5Ea_1$ and $Eb_1 = 6Ea_1$.

The light receiving devices 25a and 25b are connected to head operating unit (omitted from illustration). The head operating unit feedback-controls the combination head 21 in the ± Y directions so as to make outputs Ea1 and Eb1 from the light receiving devices 25a and 25b to hold the relationship $Eb1 = m \times Ea1$. As a result, the relative positions between the magnetic tape 23 and the combination head 21 are held at predetermined positions as described above.

As shown in Figs. 3a, 3b, light emitting unit 26 capable of emitting light of a sufficient quantity to the light receiving devices 25a and 25b is disposed in a portion confronting the light receiving devices 25a and 25b with the - Y directional end of the magnetic tape 23 disposed therebetween.

When all of the tracks T_1 to T_{48} including the tracks T_1, T_{13}, T_{25}, and T_{37} are subjected to the data reproduction operation of the magnetic recording/reproducing apparatus structured as described above, the combination head 21 is operated by the head operating unit so that the reproducing head R_1 and the track T_1, the reproducing head R_3 and the track T_{13}, the reproducing head R_5 and the track T_{25} and the reproducing head R_7 and the track T_{37} are moved to the corresponding relative positions with respect to the magnetic tape 23. At this time, the head operating unit moves the combination head 21 so as to make the output Ea_1 from the light receiving device 25a and the output Eb_1 from the light r ceiving device 25b hold the following relationship:

$Eb1 = Ea_1$

Furthermore, the head operating unit make the combination head 21 follow the weaving of the magnetic tape 23 so that the relative positions between the magnetic tape 23 and the combination head 21 are maintained. Therefore, the relative position between the combination head 21 and the magnetic tape 23 can be held correctly. In this state, when the magnetic tape 23 is allowed to run in the X direction, the data on the tracks T_1, T_{13}, T_{25} and T_{37} are reproduced by the reproducing heads R_1, R_3, R_5 and R_7. When the reproduction to the end portion of the magnetic tape 23 has been completed, the magnetic tape 23 is allowed to run in the - X direction so that the each data on the tracks T_7, T_{19}, T_{31} and T_{43} is reproduced by the reproducing heads R_2, R_4, R_6 and R_8 respectively.

When data reproduction for one reciprocation has been completed, the combination head 21 is moved by the head operating unit to the relative position of the magnetic tape 23 at which the reproduction head R_1 corresponds to the track T_2, the reproduction head R_3 corresponds to the track T_{14}, the reproduction head R_5 corresponds to the track T_{26} and the reproduction head R_7 corresponds to the track T_{38}. At this time, the head operating unit moves the combination head 21 so as to make the output Ea1 from the light receiving device 25a and the output Eb_1 from the light receiving device 25b to hold the following relationship:

$Eb_1 = 2Ea_1$

When the magnetic tape 23 is allowed to run in the X direction, data on the tracks T_2, T_{14}, T_{26} and T_{38} is reproduced by the reproducing heads R_1, R_3, R_5 and R_7. Then, the magnetic tape 23 is allowed to run in the - X direction so that each data on the tracks T_8, T_{20}, T_{32} and T_{44} is reproduced respectively. Then, the similar operation is repeated until the magnetic tape 23 is reciprocated 6 times so that data on all of the tracks T_1 to T_{48} is reproduced. The above-described operation is similarly applied to the recording operation.

In general, the output from the light receiving device such as a photo-diode and that from the light emitting unit such as a light emitting diode can be easily changed due to the influence of the ambient temperature. However, the tracking control device according to this embodiment is structured such that the output Eb_1 from the light receiving device 25b for detecting the relative position is an integer multiple of the output Ea_1 from the reference-outputting light receiving device 25a at each of the relative positions between the magnetic

tape 23 and the combination head 21. Therefore, the position control can be stably controlled without an influence of temperature.

The positions of the light receiving devices 25a and 25b are not limited to the above-described description in which they are disposed at the - Y directional end of the magnetic tape 23. Another structure may be employed in which they are disposed at the + Y directional end of the magnetic tape 23. In this case, the area of appearance of the light receiving surface of the light receiving device 25b is decreased in accordance with the movement of the combination head 21 in the direction - Y. This structure may also be applied to the following embodiments.

A second embodiment of the present invention will be described with reference to Figs. 4 and 5. The elements having the same functions as those shown in the aforesaid embodiment are given the same reference numerals and their descriptions are omitted.

As shown in Figs. 4, 5a and 5b, the magnetic recording/reproducing apparatus according to this embodiment includes a combination head 21 for recording/reproducing data from the magnetic tape 23, the combination head 21 having a slit plate 27 integrally formed with the combination head 21. The structure of the magnetic tape 23 and that of the combination head 21 can be the same as those according to the first embodiment.

A light-receiving device holding member 22 is disposed to the side of the slit plate 27 opposite to the side confronting the magnetic tape 23, the light-receiving device holding member 22 being formed independently from the combination head 21 and the slit plate 27. The light-receiving device holding member 22 has a reference-outputting light receiving device 28a serving as the first light receiving device and a light receiving device 28b for detecting the relative position and serving as the second light receiving device at a position corresponding to the - Y directional end of the magnetic tape 23, the light receiving devices 28a and 28b being disposed in the direction X. The large portion of the light receiving surface of the light receiving device 28a and that of 28b are positioned in the direction - Y by larger degrees than the - Y directional end of the magnetic tape 23. The light receiving surface of the light receiving device 28a and that of 28b are arranged such that the X directional width ℓ_H is larger than the X directional width f of a reference opening 27a and that of an opening 27b for detecting the relative position. On the other hand, the Y directional width ℓ_V is larger than the Y directional width e_2 of an opening 27b for detecting the relative position. The output levels for a unit area of the two light receiving devices 28a and 28b are arranged to be the same. The above-described slit plate 27 has the referenc opening 27a serving as the first op ning and an opening 27b for detecting the relative position and serving as the second opening. The reference opening 27a is arranged such that its Y directional opening width e1 is 120 µm which is the same width as that of the tracks T_1 to T_{48} while its X directional opening width is f with which a sufficient output level can be obtained. The opening 27b for detecting the relative position is formed near the reference opening 27a and it has the X directional width of f and whose Y directional width e_2 has a proper value holding the relationship $e_2 \geq 720$ µm. The reference opening 27a is positioned such that it is not concealed by the magnetic tape 23. Furthermore, when the reference opening 27a moved in the direction Y in accordance with the movement of the combination head 21 in the direction Y, it is arranged so as to exist within the light receiving surface of the light receiving device 28a for all of the movement range of the reference opening 27a. The opening 27b for detecting the relative positions is provided such that it - Y directional end appears from the - Y directional end of the magnetic tape 23 when the recording head W_1 and the reproducing head R_1 are at the track position T_1. Furthermore, it is structured such that its opening area appearing from the magnetic tape 23 becomes enlarged and the appearance area of the light receiving surface of the light receiving device 28a is increased in accordance with the movement of the combination head 21 in the direction - Y and the appearance area of the light receiving surface of the light receiving device 28a is increased. When the combination head 21 moved to each of the relative positions with respect the magnetic tape 23, output Ea_2 from the light receiving device 28a due to light which passed through the reference opening 27a and output Eb_2 from the light receiving device 28b due to light which passed through the opening 27b for detecting the relative position have the following relationship:

$Eb_2 = m \times Ea_2$ ($1 \leq m$, where m represents a positive integer)

The above-described numeral m represents the each of the relative positions between, for example, the reproducing head R_1 of the combination head 21 and the plurality of tracks T_1 to T_6 positioned in a range in which the reproducing head R_1 can move, the numeral m can be a different value in accordance with each of the relative positions. That is, according to this embodiment, when the recording head W_1 moved to, for example, the positions of the tracks T_1, T_2, T_3, T_4, T_5 and T_6, the each of the following relationships is stablished: $Eb_2 = Ea_2$, $Eb_2 = 2Ea_2$, $Eb_2 = 3Ea_2$, $Eb_2 = 4Ea_2$, $Eb_2 = 5Ea_2$ and $Eb_2 = 6Ea_2$.

The light receiving devices 28a and 28b are

connected to h ad operating unit (omitted from illustration). The head operating unit feedback-controls the combination head 21 in the ± Y directions so as to make the outputs Ea_2 and Eb_2 from the light receiving devices 28a and 28b to hold the relationship $Eb_2 = m \times Ea_2$. As a result, the relative positions between the magnetic tape 23 and the combination head 21 are held at a predetermined positions as described above.

As shown in Figs. 5a, 5b, the light emitting unit 26 is disposed in a portion confronting the reference opening 27a and the opening 27b for detecting the relative position in the slit plate 27 with the - Y directional end of the magnetic tape 23 disposed therebetween.

When all of the tracks T_1 to T_{48} including the tracks T_1, T_{13}, T_{25}, and T_{37} are subjected to the data reproduction operation of the magnetic recording/reproducing apparatus structured as described above, the combination head 21 is operated by the head operating unit so that the reproducing head R_1 and the track T_1, the reproducing head R_3 and the track T_{13}, the reproducing head R_5 and the track T_{25} and the reproducing head R_7 and the track T_{37} are moved to the corresponding relative positions with respect to the magnetic tape 23. At this time, the head operating unit moves the combination head 21 so as to make the output Ea_2 from the light receiving device 28a and the output Eb_2 from the light receiving device 28b hold the following relationship:

$Eb_2 = Ea_2$

Furthermore, the head operating unit make the combination head 21 follow the weaving of the magnetic tape 23 so that the relative positions between the magnetic tape 23 and the combination head 21 are maintained. In this case, when the magnetic tape 23 is allowed to run in the X direction, the data on the tracks T_1, T_{13}, T_{25} and T_{37} are reproduced. On the other hand, when the magnetic tape 23 is allowed to run in the - X direction, the data on the tracks T_7, T_{19}, T_{31} and T_{43} are reproduced.

When data reproduction for one reciprocation has been completed, the head operating unit feedback-controls to move the combination head 21 so as to make the output Ea_2 from the light receiving device 28a and the output Eb_2 from the light receiving device 28 establish the following relationship:

$Eb_2 = 2\ Ea_2$

When the magnetic tape 23 is allowed to run in the X direction, each data on the tracks T_2, T_{14}, T_{26} and T_{38} is reproduced respectively. Then, the magnetic tape 23 is allowed to run in the - X direction so that each data on the tracks T_8, T_{20}, T_{32} and T_{44} is reproduced respectively. Then, the similar operation is repeated so that data on all of the tracks T_1 to T_{48} is reproduced. The above-described operation is similarly applied to the recording operation.

According to this mbodiment, the control is performed such that the quantity of light made incident upon the light receiving devices 28a and 28b after it passed through the - Y directional end of the magnetic tape 23, the reference opening 27a and the opening 27b for detecting the relative position is detected and the output Eb_2 from the light receiving device 28b becomes an integer multiple of the output Ea_2 from the light receiving device 28a. Therefore, the tracking control similar to the first embodiment can be performed. According to this embodiment, since the structure is arranged such that the slit plate 27 is moved together with the combination head 21, the weight of the movable portion can be reduced in comparison to the first embodiment.

Similarly to the first embodiment, the position control can be stably controlled without an influence of temperature.

Then, a third embodiment of the tracking control device of a magnetic recording/reproducing apparatus according to the present invention will be described with reference to Figs. 6 and 7.

As shown in Figs. 6, 7a and 7b, the magnetic recording/reproducing apparatus includes a combination head 21 for recording/reproducing data from a magnetic tape 23, the combination head 21 having a light receiving device holding member 29 formed integrally with the combination head 21.

The above-described magnetic tape 23 has the-track group 24 constituted by the 48 tracks T_1 to T_{48} formed in the Y direction at the same pitch as shown in Fig. 6. According to this embodiment, width C of the magnetic tape 23 is arranged to be 1/4 inch and the track pitch is arranged to be 120 µm.

The combination head 21 includes 8 recording heads W_1 to W_8 and reproducing heads R_1 to R_8 which are integrally formed with the combination head 21. The recording heads W_1 to W_8 are disposed in the Y direction at a pitch of 720 µm, while the reproducing heads R_1 to R_8 are disposed in the X or - X direction with forming pairs with the corresponding recording W_1 to W_8. The recording heads W_1 to W_8 and the reproducing heads R_1 to R_8 which form pairs are alternately disposed in the Y direction. When the magnetic tape 23 is allowed to run in the X direction, the four recording heads W_1, W_3, W_5 and W_7 of the combination head 21 perform the recording, while the magnetic tape 23 is allowed to run in the - X direction, the four recording heads W_2, W_4, W_6 and W_8 perform the recording. Furthermore, whenever the magnetic tape 23 reciprocates once, the combination head 21 is moved in the - Y direction so that the com-

bination head 21 is positioned at 6 relative positions with respect to the magnetic tape 23. As a result, all of the 48 tracks T_1 to T_{48} are subjected to the data recording/reproducing. Furthermore, the light-receiving device holding member 29 has light receiving device group 30 consisting of five light receiving devices Da_1 to Da_5 at positions corresponding to the - Y directional end portion of the magnetic tape 23. The light receiving devices Da1 to Da5 are arranged to have the same output level and to be moved in accordance with the movement of the combination head 21 in the ± Y directions since the light-receiving device holding member 29 is integrally formed with the combination head 21. The light receiving surface of each of the light receiving devices Da1 to Da5 is arranged such that its X directional width is f with which a sufficient output level can be obtained. The light receiving device Da_1 is positioned at the largest degree in the - Y direction. The light receiving devices Da2 to Da4 are respectively positioned such that their -Y directional ends are successively shifted by 120 µm in the + Y direction which corresponds to the width of the each of the tracks T_1 to T_{48}. The light receiving device Da_5 is positioned from the - Y directional end by 240 µm in the + Y direction. That is, pitch d_1 between the light receiving devices Da_1 and Da_2, pitch d_2 between the light receiving devices Da_2 and Da_3 and pitch d_3 between the light receiving devices Da_3 and Da_4 are respectively arranged to be 120 µm. On the other hand, pitch d_4 between the light receiving devices Da_4 and Da_5 is arranged to be 240 µm The relationship among the light receiving devices Da_1 to Da_5 and the pitches d_1 to d_5 are arranged as follows assuming that the i-th pitch in the + Y direction is di and the width of each of the tracks T_1 to T_{48} is d:

$di = d$ when $i \leq 2$

$di = (i - 2) \times d$ when $3 \leq i \leq n - 1$

(where i and n respectively represent positive integers)

According to this embodiment, the structure is arranged such that when, for example, the recording head W_1 and the reproducing head R_1 of the combination head 21 are at the track position T_1, the light receiving device Da_1 is positioned at which it appears by 3d from the - Y directional end of the magnetic tape 23. According to this embodiment, when the recording head W_1 moved to, for example, the positions of the tracks T_1, T_2, T_3, T_4, T_5 and T_6, the following relationships among the outputs Ea_1 to Ea_5 from the light receiving devices Da_1 to Da_5 are established: $Ea_3 = Ea_1 - Ea_2$, $Ea_4 = Ea_1 - Ea_2$, $Ea_4 = Ea_1 - Ea_3$, $Ea_5 = Ea_1 - Ea_2$, $Ea_5 = Ea_1 - Ea_3$, $Ea_5 = Ea_1 - Ea_4$.

The light receiving devices Da_1 to Da_5 are connected to head operating unit (omitted from illustration). The head operating unit feedback-controls the combination head 21 in the ± Y directions so as to make the outputs Ea_1 and Ea_5 from the light receiving devices Da_1 to Da_5 t hold the above-described relationship when the combination head 21 moved to the relative positions among the recording heads W_1 to W_8, the reproducing heads R_1 to R_8 and the tracks T_1 to T_{48}. As a result, the relative positions between the magnetic tape 23 and the combination head 21 are held at a predetermined positions as described above.

As shown in Figs. 7a, 7b, light emitting unit 26 capable of emitting light of a sufficient quantity to the light receiving devices Da_1 to Da_5 is disposed in a portion confronting the light receiving devices Da_1 to Da_5 with the - Y directional end of the magnetic tape 23 disposed therebetween.

When all of the tracks T_1 to T_{48} including the tracks T_1, T_{13}, T_{25}, and T_{37} are subjected to the data reproduction operation of the magnetic recording/reproducing apparatus structured as described above, the combination head 21 is operated by the head operating unit so that the reproducing head R_1 and the track T_1, the reproducing head R_3 and the track T_{13}, the reproducing head R_5 and the track T_{25} and the reproducing head R_7 and the track T_{37} are moved to the corresponding relative positions with respect to the magnetic tape 23. At this time, the head operating unit moves the combination head 21 so as to make the output Ea_1 from the light receiving device Da_1 and the output Ea_2 from the light receiving device Da_2 hold the following relationship by the feedback control:

$Ea_3 = Ea_1 - Ea_2$

Furthermore, the head operating unit make the combination head 21 follow the weaving of the magnetic tape 23 so that the relative positions between the magnetic tape 23 and the combination head 21 are maintained. Therefore, the relative position between the combination head 21 and the magnetic tape 23 can be held correctly. In this case, when the magnetic tape 23 is allowed to run in the direction X, the data on the tracks T_1, T_{13}, T_{25} and T_{37} are reproduced by the reproducing heads R_1, R_3, R_5 and R_7. When the reproduction to the end portion of the magnetic tape 23 has been completed, the magnetic tape 23 is allowed to run in the direction - X so that the data on the tracks T_7, T_{19}, T_{31} and T_{43} is reproduced by the reproducing heads R_2, R_4, R_6 and R_8.

When data reproduction for one reciprocation has been completed, the combination head 21 is moved by the head operating unit to the relative position of the magnetic tape 23 at which the reproduction head R_1 corresponds to the track T_2, th reproduction head R_3 corresponds to the track T_{14}, the reproduction head R_5 corresponds to the

track T_{26} and the reproduction head R_7 corresponds to the track T_{38}. At this time, the head operating unit moves the combination head 21 so as to make the output Ea_1 from the light receiving device Da_1 and the output Ea_2 from the light receiving device Da_2 and the output Ea_4 from the light receiving device Da_4 establish the following relationship by the feedback control:

$Ea_4 = Ea_1 - Ea_2$

When the magnetic tape 23 is allowed to run in the direction X in this state, data on the tracks T_2, T_{14}, T_{26} and T_{38} is reproduced by the reproducing heads R1, R3, R5 and R7. Then, the magnetic tape 23 is allowed to run in the direction - X so that data on the tracks T_8, T_{20}, T_{32} and T_{44} is reproduced.

Similarly, the combination head 21 is moved after the one reciprocation at each of the track positions so as to hold the following relationships:

when data on tracks T_3, T_{15}, T_{27}, T_{39} and tracks T_9, T_{21}, T_{33}, T_{44} are reproduced,

$Ea_4 = Ea_1 - Ea_3$

when data on tracks T_4, T_{16}, T_{28}, T_{40} and the tracks T_{10}, T_{22}, T_{34}, T_{46} are reproduced

$Ea_5 = Ea_1 - Ea_2$

when data on tracks T_5, T_{17}, T_{29}, T_{41} and tracks T_{11}, T_{23}, T_{35}, T_{47} are reproduced

$Ea_5 = Ea_1 - Ea_3$

when data on tracks T_6, T_{18}, T_{30}, T_{42} and tracks T_{12}, T_{24}, T_{36}, T_{48} are reproduced

$Ea_5 = Ea_1 - Ea_4$

As a result, the track switching operation and the track followup operation are executed so that the data on all of the tracks T_1 to T_{48} are reproduced. The above-described operation is applied to the data recording operation.

According to this embodiment, since the structure is arranged such that the difference in output between two predetermined light receiving devices becomes the same as the output from a predetermined light receiving device, the position control can be stably obtained without an influence of temperatue.

According to this embodiment, the numbers of the relative positions between the magnetic tape 23 and the combination head 21 are arranged to be six. The number of the light receiving devices for detecting a plurality of relative positions can be reduced by increasing the number of the relative positions.

The positions of the light receiving devices Da_1 to Da_5 are not limited to the above-described structure in which they are positioned at the - Y directional end of the magnetic tape 23. A structure may be employed in which they are positioned at the + Y directional end of the magnetic tape 23 and the appearance area of the light receiving surface of each of the light receiving devices Da_1 to Da_5 decreases in accordance with the mov ment of th combination head 21 in the - Y direction. The above-described structure may be applied to th following embodiments.

Then, a fourth embodiment of the present invention will be described with reference to Figs. 8 and 9. In order to make the description easier, the elements having the same function as those in the above-described embodiments are given the same reference numerals and their descriptions are omitted.

As shown in Figs. 8, 9a and 9b, the magnetic recording/reproducing apparatus according to this embodiment includes a combination head 21 for recording/reproducing data from the magnetic tape 23, the combination head 21 having a slit plate 31 integrally formed with the combination head 21. The structure of the magnetic tape 23 and that of the combination head 21 are arranged to be the same as those according to the third embodiment.

A light-receiving device holding member 32 is disposed to the side of the slit plate 31 opposite to the side confronting the magnetic tape 23, the light-receiving device holding member 32 being formed independently from the combination head 21 and the slit plate 31. The light-receiving device holding member 32 has five light receiving devices Db_1 to Db_5 at a positions corresponding to the - Y directional end of the magnetic tape 23, the light receiving devices Db_1 to Db_5 being disposed in the X direction. The light receiving devices Db_1 to Db_5 are arranged to independently receive light which passed through the - Y directional end of the magnetic tape 23 and openings A_1 to A_5 to be described later. The light receiving surface of each of the light receiving devices Db_1 to Db_5 is arranged to be elongated in the Y direction, and the large portion of the light receiving surface of them are positioned in the - Y direction by larger degrees than the - Y directional end of the magnetic tape 23. The light receiving surface of each of light receiving devices Db_1 to Db_5 are arranged such that the X directional width ℓ_H is larger than the X directional width f of each of openings A_1 to A_5. Furthermore, the Y-directional width ℓ_V is arranged to be a value which corresponds to the Y-directional movement of the openings A_1 to A_5. The output levels for a unit area of the light receiving devices Db_1 to Db_5 are arranged to be the same.

The above-described slit plate 31 has the openings A_1 to A_5. The openings A_1 to A_5 are arranged such that its X directional opening width is f with which a sufficient output level can be obtained from the light receiving devices Db_1 to Db_5. The opening A_1 is positioned at the largest degree in the - Y direction. The openings A_2 to A_4 are respectively positioned such that their - Y directional ends are successively shifted by 120 µm in the + Y direction which corresponds to the

width of the each of the tracks T_1 to T_{48} from the - Y directional end of the opening A_1. The opening A_5 is positioned from the - Y directional end by 240 µm in the + Y direction. That is, pitch d_1 between the opening A_1 and Db_2, pitch d_2 between the opening A_2 and Db_3 and pitch d_3 between the opening A_3 and Da_4 are respectively arranged to be 120 µm. On the other hand, pitch d_4 between the openings A_4 and A_5 is arranged to be 240 µm. The relationship among the opening A_1 to A_5 and the pitches d_1 to d_5 are arranged as follows assuming that the i-th pitch in the + Y direction is d_i and the width of each of the tracks T_1 to T_{48} is d:

$di = d$ when $i \leq 2$

$di = (i - 2) \times d$ when $3 \leq i \leq n - 1$

(where i and n respectively represent positive integers)

According to this embodiment, the structure is arranged such that when, for example, the recording head W_1 and the reproducing head R_1 of the combination head 21 are at the track position T_1, the opening A_1 is positioned at which it appears by 3d from the - Y directional end of the magnetic tape 23. According to this embodiment, when the recording head W_1 moved to, for example, the positions of the tracks T_1, T_2, T_3, T_4, T_5 and T_6, the following relationships among the outputs Eb_1 to Eb_5 from the light receiving devices Db_1 to Db_5 due to light which passed through the openings A_1 to A_5 and the - Y directional end of the magnetic tape 23 are established: $Eb_3 = Eb_1 - Eb_2$, $Eb_4 = Eb_1 - Eb_2$, $Eb_4 = Eb_1 - Eb_3$, $Eb_5 = Eb_1 - Eb_2$, $Eb_5 = Eb_1 - Eb_3$, $Eb_5 = Eb_1 - Eb_4$.

The light receiving devices Db_1 to Db_5 are connected to head operating unit (omitted from illustration). The head operating unit feedback-controls the combination head 21 in the ± Y directions so as to make the outputs Eb_1 and Eb_5 from the light receiving devices Db_1 to Db_5 hold the above-described relationship when the combination head 21 moved to the relative positions among the recording heads W_1 to W_8 and the reproducing heads R_1 to R_8 and the tracks T_1 to T_{48}. As a result, the relative positions between the magnetic tape 23 and the combination head 21 are held at a predetermined positions as described above.

As shown in Figs. 9a, 9b, light emitting unit 26 capable of emitting light of a sufficient quantity to the light receiving devices Db_1 to Db_5 is disposed in a portion confronting the light receiving devices Db_1 to Db_5 with the - Y directional end of the magnetic tape 23 and the openings A_1 to A_5 formed in the slit plate 31 disposed therebetween.

When all of the tracks T_1 to T_{48} including the tracks T_1, T_{13}, T_{25}, and T_{37} are subjected to the data reproduction operation of the magnetic recording/reproducing apparatus structured as described above, the combination head 21 is operated by the head operating unit so that the reproducing head R_1 and the track T_1, the reproducing head R_3 and the track T_{13}, the reproducing head R_5 and the track T_{25} and the reproducing head R_7 and the track T_{37} are moved to the corresponding relative positions with respect to the magnetic tape 23. At this time, the head operating unit moves the combination head 21 so as to make the output Eb_1 from the light receiving device Db_1, the output Eb_2 from the light receiving device Db_2 and the output Eb_3 from the light receiving device Db_3 hold the following relationship by the feedback control:

$Eb_3 = Eb_1 - Eb_2$

Therefore, the head operating unit make the combination head 21 follow the weaving of the magnetic tape 23 so that the relative positions between the magnetic tape 23 and the combination head 21 are maintained. In this case, when the magnetic tape 23 is allowed to run in the X direction, the data on the tracks T_1, T_{13}, T_{25} and T_{37} are reproduced by the reproducing heads R_1, R_3, R_5 and R_7. When the magnetic tape 23 is allowed to run in the -X direction, the data on the tracks T_7, T_{19}, T_{31} and T_{43} are reproduced by the reproducing heads R_2, R_4, R_6 and R_8.

Similarly, the combination head 21 is moved after the one reciprocation at each of the track positions so as to hold the following relationships:

When data on the tracks T_2, T_{14}, T_{26}, T_{38} and the tracks T_8, T_{20}, T_{32}, T_{44} are reproduced,

$Eb_4 = Eb_1 - Eb_2$

When data on tracks T_3, T_{15}, T_{27}, T_{39} and tracks T_9, T_{21}, T_{33}, T_{45} are reproduced,

$Eb_4 = Eb_1 - Eb_3$

When data on tracks T_4, T_{16}, T_{28}, T_{40} and the tracks T_{10}, T_{22}, T_{34}, T_{46} are reproduced

$Eb_5 = Eb_1 - Eb_2$

When data on tracks T_5, T_{17}, T_{29}, T_{41} and tracks T_{11}, T_{23}, T_{35}, T_{47} is reproduced

$Eb_5 = Eb_1 - Eb_3$

When data on tracks T_6, T_{18}, T_{30}, T_{42} and tracks T_{12}, T_{24}, T_{36}, T_{48} is reproduced

$Eb_5 = Eb_1 - Eb_4$

As a result, the track switching operation and the track followup operation are executed so that the data on all of the tracks T_1 to T_{48} is reproduced. The above-described operation is applied to the data recording operation. As described above, since the structure according to this embodiment is arranged such that the slit plate 31 is moved together with the combinati n head 21, the weight of the movable portion can be reduced in comparison to the structure according to the third embodiment.

Similarly to the first embodiment, a stable position control can be obtained without an influ nce of temperature.

Th n a fifth embodiment of the tracking control

device of a magnetic recording/reproducing apparatus will be described with reference to Figs. 10 and 11.

As shown in Figs. 10, 11a and 11b, the magnetic recording/reproducing apparatus includes the combination head 21 for recording and reproducing data from the magnetic tape 23 and having a light-receiving device holding member 34 formed integrally with the combination head 21.

The above-described magnetic tape 23 has a track group 24 constituted by the 48 tracks T_1 to T_{48} formed in the direction Y at the same pitch as shown in Fig. 10. According to this embodiment, width C of the magnetic tape 23 is arranged to be 1/4 inch and the track pitch is arranged to be 120 µm. The weaving taken place in the magnetic tape 23 is restricted to smaller than ± 50 µm by flanges or the like (omitted from illustration) for ± Y directional end of the magnetic tape 23.

The combination head 21 includes 8 recording heads W_1 to W_8 and reproducing heads R_1 to R_8 which are integrally formed with the combination head 21. The recording heads W_1 to W_8 are disposed in the Y direction at a pitch of 720 µm, while the reproducing heads R_1 to R_8 are disposed in the X or - X direction with forming pairs with the corresponding recording heads W_1 to W_8. The recording heads W_1 to W_8 and the reproducing heads R_1 to R_8 which form pairs are alternately disposed in the Y direction. When the magnetic tape 23 is allowed to run in the X direction, the four recording heads W_1, W_3, W_5 and W_7 of the combination head 21 perform the recording, while the magnetic tape 23 is allowed to run in the direction - X, the four recording heads W_2, W_4, W_6 and W_8 perform the recording. Furthermore, whenever the magnetic tape 23 reciprocates once, the combination head 21 is moved in the - Y direction so that the combination head 21 is positioned at 6 relative positions with respect to the magnetic tape 23. As a result, all of the 48 tracks T_1 to T_{48} are subjected to the data recording/reproducing. Furthermore, light receiving device group 34 serving as a light receiving device group on one end and consisting of six light receiving devices Da_1 to Da_6 is provided in a portion corresponding to the portion in the vicinity of the + Y directional end of the magnetic tape 23. Similarly, light receiving device group 35 serving as a light receiving device group on another end and consisting of six light receiving devices Db_1 to Db_6 is provided in a portion corresponding to the portion in the vicinity of the - Y directional end of the magnetic tape 23. The number of the light receiving devices of the light receiving device groups 34 and 35 is arranged to be six which is the sam as the number of the tracks T_1 to T_6 in a range in which, for example, the recording head W_1 and the reproducing head R_1 of the combination head 21 can be moved. The light receiving devices Da_1 to Da_6 and Db_1 to Db_6 ar arranged to hav the same output level. Furthermore, the light-receiving device holding member 33 is integrally formed with the combination head 21. As a result, the light receiving devices Da_1 to Da_6 and Db_1 to Db_6 can be moved in accordance with the movement of the combination head 21 in the ± Y directions. The light receiving surface of each of the light receiving devices Da_1 to Da_6 and Db_1 to Db_6 is arranged to have the Y-directional width e which can correspond to the weaving of the magnetic tape 23. The X-directional width is arranged to be f with which a sufficient output can be obtained. According to this embodiment, the above-described width e is 100 µm. The light receiving devices Da_1 to Da_6 and Db_1 to Db_6 are arranged such that the light receiving devices Da_1 and Db_1 are disposed at the - Y directional end and the light receiving devices Da_2 to Da_6 and Db_2 to Db_6 are formed in the + Y direction to form a line at the same pitch d (d = 120 µm) as the track pitch of the magnetic tape 23. The light receiving devices Da_1 and Db_1 are shifted by 1/4 inch in the direction Y of the magnetic tape 23. Furthermore, when, for example, the recording head W_1 and the reproducing head R_1 of the combination head 21 is at the track position T_1, the center of the light receiving devices Da_1 and that of Db_1 coincide with the ± Y directional end of the magnetic tape 23.

The above-described light receiving devices Da_1 to Da_6 and Db_1 to Db_6 are connected to the head operating unit (omitted from illustration). The head operating unit feedback controls the combination head 21 so as to move it to each of the relative positions between the recording heads W_1 to W_8, the reproducing heads R_1 to R_8 and the tracks T_1 to T_{48} such that the difference in the output from the corresponding light receiving devices becomes zero, the combination head 21 being moved in the ± Y direction. As a result, the relative position between the magnetic tape 23 and the combination head 21 can be held at a predetermined position.

As shown in Figs. 11a, 11b, light emitting unit 36 capable of emitting a sufficient quantity of light to the light receiving devices 34 and 35 are disposed at positions corresponding to the light receiving device groups 34 and 35 with the ± Y directional end of the magnetic tape 23 disposed therebetween.

At this time, the head operating unit feedback controls the combination head 21 so as to move it such that the difference in the output between the light receiving device Da_1 and the light receiving device Db_1 becomes zero. Furthermore, the head operating unit make th combination head 21 follow the weaving of the magnetic tape 23 so as to maintain the relative position between the magnetic

tape 23 and the combination head 21.

When the reproduction of data for one reciprocation has been completed, the combination head 21 is moved to the relative position with the magnetic tape 23 at which the reproducing head R_1 and the track T_2 corresponds to each other, the reproducing head R_3 and the track T_{14} corresponds to each other, the reproducing head R_5 and the track T_{26} corresponds to each other and the reproducing head R_7 and the track T_{38} corresponds to each other. At this time, the head operating unit feedback-controls the combination head 21 so as to move it such that the difference in the output between the light receiving device Da_2 and that of the light receiving device Db_2 becomes zero. When the magnetic tape 23 is allowed to run in the X direction, data on the tracks T_2, T_{14}, T_{26} and T_{38} is reproduced by the reproducing heads R_1, R_3, R_5 and R_7. Then, when the magnetic tape 23 is allowed to run in the direction - X so that the tracks T_8, T_{20}, T_{32} and T_{44} are subjected to the reproduction.

Similarly, when data on the tracks T_3, T_{15}, T_{27} and T_{39} and data on the tracks T_9, T_{21}, T_{33} and T_{45} is reproduced, the combination head 21 is moved so as to make the difference in the output between the light receiving devices Da3 and Db3 becomes zero. When data on the tracks T_4, T_{16}, T_{28} and T_{40} and data on the tracks T_{10}, T_{22}, T_{34} and T_{46} is reproduced, the difference in the output between the light receiving devices Da4 and Db4 is made zero. When data on the tracks T_5, T_{17}, T_{29} and T_{41} and data on the tracks T_{11}, T_{23}, T_{35} and T_{47} is reproduced, the difference in the output between the light receiving devices Da_5 and Db_5 is made zero. When data on the tracks T_6, T_{18}, T_{30} and T_{42} and data on the tracks T_{12}, T_{24}, T_{36} and T_{48} is reproduced, the difference in the output between the light receiving devices Da_6 and Db_6, is made zero. The combination head 21 is moved after one reciprocation at each of the track position has been completed. Thus, the track switching operation and the track following-up operation are executed until data on all of the tracks T_1 to T_{48} is reproduced. The above-described operation is applied to the recording operation.

Then, a sixth embodiment of the present invention will be described with reference to Figs. 12 and 13. In order to make the description easy, the elements having the same functions as those according to the aforesaid embodiments are given the same reference numerals and their descriptions are omitted.

As shown in Figs. 12, 13a and 13b, th magnetic recording/reproducing apparatus includes the combination head for recording and reproducing data from the magnetic tape 23, the combination head 21 having a slit plate 37 integrally formed with the combination head 21. The structures of the magnetic tape 23 and the combination head 21 are the same as those according to the fifth embodiment. The weaving of the magnetic tape 21 is restricted to ± 50 µm or less by flanges or the like (omitted from illustration) for restricting the ± Y directional end of the magnetic tape 21.

The light-receiving device holding member 38 is secured to the slit plate 37 on the side opposite to the side which confronts the magnetic tape 23, the light-receiving device holding member 38 being independently formed from the combination head 21 and the slit plate 37.

The light-receiving device holding member 38 has light receiving device groups 39 and 40 which respectively consist of six light receiving devices Di_1 to Di_6 and Dj_1 to Dj_6 at the positions corresponding to the ± Y directional ends of the magnetic tape 23. The light receiving devices Di_1 to Di_6 and Dj_1 to Dj_6 are arranged such that the light receiving devices Di_1 and Dj_1 are disposed at the + X directional end and the other light receiving devices are successively disposed in the - X direction to form a line at a pitch g. Furthermore, their y-directional centers coincide with the ± Y-directional end of the magnetic tape 23. The above-described light receiving devices Di1 to Di_6 and Dj_1 to Dj_6 are respectively arranged to independently receive light which passed through the ± Y-directional end of the magnetic tape 23 and openings Si_1 to Si_6 and Sj_1 to Sj_6 to be described later. The light receiving surfaces of the light receiving device Di_1 to Di_6 and those Dj_1 to Dj_6 are arranged such that the Y directional width ℓ_V is larger than the Y directional width e of openings Si_1 to Si_6 and Sj_1 to Sj_6, and the X directional width ℓ_H is smaller than the above-described pitch g. The output levels for a unit area of the light receiving devices Di_1 to Di_6 and Dj_1 to Dj_6 are arranged to be the same.

The above-described slit plate 37 has an opening group 41 consisting of six openings Si_1 to Si_6 and serving as an opening group at an end portion at a positions corresponding to the light receiving devices Di_1 to Di_6. On the other hand, opening group 42 consisting of six openings Sj_1 to Sj_6 and serving as an opening group at another end portion at positions corresponding to the light receiving devices Dj_1 to Dj_6. The openings are provided by six so as to correspond to the number of the tracks T_1 to T_6 in a range in which, for example, the recording head W1 and the reproducing head R1 can move which form pairs. The openings Si_1 to Si_6 and Sj_1 to Sj_6 moves in accordance with the ± Y dir ctional movement of th combination head 21 since the slit plate 37 is integrally formed with the combination head 21. Each of the openings Si_1 to Si_6 is arranged to have a Y-directional width e (e = 100 µm) so as to correspond to the weaving of the

magnetic tape 23. On the other hand, their X-directional width is arranged to be a width f with which a sufficient output can be obtained from the light receiving devices Di_1 to Di_6 and Dj_1 to Dj_6. The openings Si_1 to Si_6 and Sj_1 to Sj_6 are arranged such that the openings Si_1 and Sj_1 are disposed at the + X directional end and at the - Y directional end and the openings Si_2 to Si_6 and Sj_2 to Sj_6 are respectively and successively disposed in the + Y direction at the same pitch d (d = 120 µm) as the track pitch of the magnetic tape 23 and at a pitch g in the - X direction. Furthermore, the light receiving devices Di_1 to Di_6 and the light receiving devices Dj_1 to Dj_6 are shifted by 1/4 inch which corresponding to the width of the magnetic tape 23 in the direction Y. According to this embodiment, when for example, the recording head W_1 and the reproducing head R_1 of the combination head 21 are at the track position T1, the Y-directional centers of the openings Si_1 and Sj_1 coincide with the centers of the light receiving devices Di_1 and Dj_1, that is, the ± Y directional ends of the magnetic tape 23.

The above-described light receiving devices Di_1 to Di_6 and Dj_1 to Dj_6 are connected to the head operating unit (omitted from illustration). The head operating unit feedback-controls the combination head 21 to move it in the ± Y direction of the magnetic tape 23 such that the difference in the output between light receiving devices Di_1 to Di_6 and Dj_1 to Dj_6 which form pairs becomes zero when the combination head 21 has been shifted to each of the relative positions between the recording heads W_1 to W_8 and the reproducing heads R_1 to R_8 and the tracks T_1 to T_{48}. As a result, the relative position between the magnetic tape 23 and the combination head 21 is maintained at a predetermined position.

As shown in Figs. 13a, 13b, the light emitting unit 43 capable of emitting light to the light receiving devices 39 and 40 are provided at the positions confronting the above-described light receiving device groups 39 and 40 with the ± Y directional end of the magnetic tape 23 and the slit plate 37 disposed therebetween. At this time, the head operating unit feedback-controls to calculate the difference in the output between the light receiving device Di1 and the light receiving device Dj_1 due to incident light from the light emitting unit 43 via the openings Si_1 and Sj_1 formed in the slit plate 37 and the ± Y directional end of the magnetic tape 23. The combination head 21 is operated such that the difference in the output becomes zero. Therefore, the combination head 21 moves so as to follow the weaving f the magnetic tape 23. As a result, the relative positions between the combination head 21 and the magnetic tape 23 can be maintained correctly. When the magnetic tape 23 is allowed to run in the direction X in this state, data on the tracks T_1, T_{13}, T_{25} and T_{37} is reproduced by the reproducing heads R_1, R_3, R_5 and R_7. When the magnetic tape 23 is allowed to run in the - X direction, data on the tracks T_7, T_{19}, T_{31} and T_{43} is reproduced by the reproducing heads R_2, R_4, R_6 and R_8.

When the reproduction of data for one reciprocation has been completed, the combination head 21 is moved so as to make the following differences in the following outputs zero: when data on the tracks T_2, T_{14}, T_{26} and T_{38} and data on the tracks T_8, T_{20}, T_{32} and T_{44} is reproduced, the output difference between the light receiving devices Di_2 and Dj_2 due to incident light via the openings Si_2 and Sj_2 and the ± Y directional end of the magnetic tape 23; when data on the tracks T_3, T_{15}, T_{27} and T_{39} and data on the tracks T_9, T_{21}, T_{33} and T_{45} is reproduced, the output difference between the light receiving devices Di_3 and Dj_3 due to incidental light via the openings Si_3 and Sj_3 and the ± Y directional end of the magnetic tape 23; when data on the tracks T_4, T_{16}, T_{28} and T_{40} and data on the tracks T_{10}, T_{22}, T_{34} and T_{46} is reproduced, the output difference between the light receiving devices Di_4 and Dj_4 due to incident light via the openings Si_4 and Sj_4 and the + Y directional ends of the magnetic tape 23; when data on the tracks T_5, T_{17}, T_{29} and T_{41} and data on the tracks T_{11}, T_{23}, T_{35} and T_{47} is reproduced, output difference between the light receiving devices Di_5 and Dj_5 due to incidental light via the openings Si_5 and Sj_5 and the ± Y directional ends of the magnetic tape 23; when data on the tracks T_6, T_{18}, T_{30} and T_{42} and data on the tracks T_{12}, T_{24}, T_{36} and T_{48} is reproduced, the output difference between the light receiving devices Di6 and Dj_6 due to incident light via the openings Si_6, Sj_6 and the ± Y directional ends of the magnetic tape 23. As a result, the track switching operation and the track following up operation can be performed and the data reproduction from all of the tracks T_1 to T_{48} is completed. The above-described operation is applied to the recording operation.

Then, a seventh embodiment of the present invention will be described. According to this embodiment, an example of a serpentine magnetic recording/reproducing apparatus is provided. The magnetic recording/reproducing apparatus according to this embodiment is structured such that a combination head having recording heads and the reproducing heads whose number is smaller than the number of the tracks of the magnetic tape is allowed to run once in the direction of the magnetic tape on which a plurality f tracks are formed in parallel in the direction in which the tape runs. As a result, a plurality of tracks are simultaneously subjected to the recording or the reproducing. Further-

more, the combination head is moved by th head operating means in the widthwise direction of the magnetic tape by the track switching operation. As a result, data is recorded/reproduced from all of the tracks.

Then, the magnetic recording/reproducing apparatus according to this embodiment will be described with reference to Figs. 14, 15 and 16.

Fig. 14 is a perspective view which illustrates the magnetic recording/reproducing apparatus to which no magnetic tape has been loaded. Fig. 15 illustrates a state in which the magnetic tape has been loaded.

A combination head 51 for recording or reproducing data from a magnetic tape 52 is fastened to a holder 53 serving as a member for holding the combination head 51. A light-receiving groups 54 and 55 for detecting the vertical two ends of the magnetic tape 52 are secured to a portion in the vicinity of the combination head 51.

That is, a movable portion 56 is constituted by combining the combination head 51, the light receiving device groups 54 and 55 and the holder 53. The holder 53 is fastened between the free ends of parallel leaf springs 57a and 57b whose one ends are secured to a fastening portion 58. The fastening portion 58 is fastened to a main frame (omitted from illustration) of the magnetic recording/reproducing apparatus. As head moving unit for moving the combination head 51 to the widthwise direction of the magnetic tape 52, a voice coil type linear motor 59 having no friction loss and dead zone is employed. The voice coil type linear motor 59 includes a square yoke type magnetic circuit 60 secured to the main frame and a coil 61 for generating moving force. The above-described movable portion 56 is connected to the coil 61 by the bobbin 62 which connects the movable portion 56 and the coil 61 such that it acts in synchronization with the movement of the coil 61 and the power generated by the coil 61 passes through a portion in the vicinity of the center of gravity of the movable portion 56. As a result of the above-described structure, precise servo control can be performed in the operation of the combination head 51.

Reference numerals 60a and 60b represent magnets of the voice coil type linear motor 59. Reference numeral 60 represents a central magnet into which the coil 61 is inserted from outside. Reference numeral 60d represents an outside magnetic pole, 60e represents a common magnetic pole positioned in closely contact with th terminals of each of outer magnetic poles confronting the central magnetic pol 60C, the outer magnetic pole 60d and the outer magnetic pole 60e. Thus, a closed circuit of the magnetic circuit 60 is constituted so that the combination head 51 does not receive an influence of a leaked flux from the magnetic circuit 60. Therefore, the influence of the leaked flux from the voice coil type linear motor 59 upon the combination head 51 and the magnetic tape 52 can be reduced to ten and several Oes. Furthermore, the main frame is provided with a light emitting device 63 position in the opposite direction to the light receiving devices 54 and 55 with the magnetic tape 52 is disposed therebetween and fixed guides 64a and 64b disposed on the both sides of the combination head 51 and guiding the magnetic tape 52.

Fig. 16 illustrates the structure of the tracking control according to this embodiment. As shown in Fig. 16, the magnetic tape 65 has a track group 66 consisting of 48 tracks T_1 to T_{48} at the same pitch in the direction Y. According to this embodiment, the width c of the magnetic tape 65 is arranged to be 1/4 inch and the track pitch is arranged to be 120 µm. The combination head 67 includes 16 recording heads W_1 to W_{16} and reproducing heads R_1 to R16 which are formed integrally. The recording heads W_1 to W_{16} are disposed in the direction Y at a pitch of 360 µm. The reproducing heads R_1 to R_{16} form a pair with the corresponding recording heads W_1 to W_{16} in the X or - X direction. The recording heads W_1 to W_{16} and the reproducing heads R_1 to R_{16} each forming a pair are alternately disposed in the direction Y.

In the combination head 67 thus structured, when the magnetic tape 65 is allowed to run in the direction X, 8 recording heads W_{2n-1} (n = 1 to 8) perform the recording operation, while when the magnetic tape 65 is allowed to run in the direction - Y, 8 recording heads W_{2n} (n = 1 to 8) perform the recording. Furthermore, the combination head 67 is moved in the direction - C whenever the magnetic tape reciprocates. Therefore, the relative position with respect to the magnetic tape 65 is changed three times. As a result, all of the 48 tracks T_1 to T_{48} are subjected to the data recording/reproducing. The holder 68 has, at its portion corresponding to the + Y directional end of the magnetic tape 65, a light-receiving device group 69 consisting of three light receiving devices Da_1 to Da_3 and disposed at an end. Furthermore, a light-receiving device group 70 consisting of three light receiving devices Db_1 to Db_3 and disposed at the other end is provided in a portion corresponding to the - Y directional end. The number of the provided light receiving devices 69 and 70 corresponds to the number of the tracks T_1 to T_3 in a range in which, for xample, the pair of the recording head W_1 and the reproducing head R_1 of the combination head 67. Th light receiving devices Da_1 to Da_3 and Db_1 to Db_3 are arranged to have the same output level for a unit light receiving area. Furthermore, they are integrally formed with the

combination head 67 by the holder 68. As a result, they can be moved in accordance with the movement of the combination head 67 in the ± direction Y. The light receiving devices Da_1 to Da_3 and Db_1 to Db_3 are disposed at the same pitch (120 µm) as the track pitch of the magnetic tape 65, and the light receiving device Da_1 and Db1 are shifted from each other in the direction Y by the width (1/4 inch) of the magnetic tape 65. Furthermore, when, for example, the recording head W_1 and the reproducing head R_1 of the combination head 67 are at the track position T_1, the centers of the light receiving devices Da_1 and Db_1 coincide with the ± Y directional ends of the magnetic tape 65.

As a result of the above-described structure, when data on all of the tracks T_1 to T48 is reproduced, the head operating unit is feedback-controlled so as to make the output difference between the light receiving devices Da_1 and Db_1 becomes zero when the magnetic tape 65 is allowed to run in the direction X. With the thus realized precise tracking control performed, data on 8 tracks T_{6n-5} (n = 1 to 8) is reproduced by 8 reproducing heads R_{2n-1} (n = 1 to 8). When the reproduction to the end portion of the magnetic tape 65 has been ended, the magnetic tape 65 is allowed to run in the direction - X. During this, the feedback control such that the output difference between the light receiving devices Da_1 and Db_1 is made zero is conducted so that the data on 8 tracks T_1 to T_{6n-3} - (n = 1 to 8) is reproduced by 8 reproducing head R_{2n-1} (n = 1 to 8). Similarly, the track switching operation and the track follow-up operation are conducted. Thus, data on all of the tracks T_1 to T_{48} is ended. The above-described operation is also applied to the recording operation.

Although the combination head 67 is held by a parallel leaf spring according to this embodiment, the present invention is not limited to the description above. A structure may be employed in which it is held by a shaft and a bearing in a sliding method.

Fig. 17 illustrates the transfer function of the spring system of the parallel leaf spring supporting structure shown in Figs. 14 and 15. As shown in Fig. 17, the second resonance frequency becomes 1.2 kHz with respect to the first resonance frequency 30 Hz. With the characteristics described above, the closed loop servo with the cutoff frequency of about 500 Hz can be obtained by performing a servo control such as the phase compensation. Therefore, the tape weaving of, for example, 100 Hz can be followup controlled at a compression ratio of about -20 to -30 dB.

Fig. 18 illustrates the transfer function for a structure in which the combination head 51 and the holder 53 are not supported between the parallel leaf springs 57a and 57b Figs. 14 and 15. Since the second resonant frequency is about 450 Hz, the cutoff frequency becomes lowered excessively and the servo gain reduction becomes too lowered to conduct the closed loop servo. Therefore, a tracking control with a satisfactory followup characteristics cannot be conducted.

Since the voice type linear motor 59 is used to operate the combination head 51 and since the power generated by the linear motor 59 is arranged to pass through a portion in the vicinity of the center of gravity of the movable portion 56, the operation of the combination heads 51 can be precisely servo-controlled.

Many widely different embodiments of the present invention may be constructed without departing from the spirit and scope of the present invention. It should be understood that the present invention is not limited to the specific embodiments described in this specification, except as defined in the appended claims.

Claims

1. A magnetic recording/reproducing apparatus of serpentine system capable of recording/reproducing a large amount of high density data at high speed with a tracking control for precisely positioning a combination head, said apparatus comprising:
a combination head having a magnetic head corresponding to a magnetic tape formed by a plurality of tracks arranged in parallel to one another in a direction in which said magnetic tape runs;
light emitting means disposed at a position confronting one side of said magnetic tape for emitting light in a widthwise direction of said magnetic tape;
light receiving means having a plurality of light receiving elements disposed at a position confronting the other side of said magnetic tape for receiving said light emitted from said light emitting means such that said light receiving means are so disposed that outputs from said light receiving elements have a predetermined relation which governs said feedback control at a time when said magnetic head moved to a predetermined track position; and
head operating means capable of moving said combination head in said widthwise direction of said magnetic tape.

2. An apparatus according to claim 1, wherein said combination head includes said light receiving elements whose number is the same as the number of said plurality of said tracks at end portion and at the other end portion in said widthwise direction of said magnetic tape, said light receiving elements disposed at said end portion are arranged in parallel with light receiving elements disposed at

said the other portion in a pair correspond to a predetermined track of said magnetic tape.

3. An apparatus according to claim 1, wherein said light emitting means is disposed at a position which confronts said light receiving elements via two end portions of said magnetic tape.

4. An apparatus according to claim 1, wherein said light receiving means is formed integrally with said combination head and has a first light receiving element of a light receiving area Sa_1 and a second light receiving element of a light receiving area Sb_1 with a relation of $Sb_1 \geq n \times Sa_1$ where n represents a positive integer, and said predetermined relation is $Eb_1 = m \times Ea_1$ where m represents a positive integer satisfying $1 \leq m \leq n$ and differs in accordance with each of relative positions between said magnetic head and said plurality of tracks in a movable range of said magnetic head.

5. An apparatus according to claim 1, wherein said light receiving means is formed integrally on said combination head and has n pieces of light receiving elements of Da_1 to Da_n with the same width in a direction in which said magnetic tape runs, where n represents a positive integer satisfying the relation of $n \geq 3$, a direction of said widthwise end portion of said magnetic tape is arranged to be - Y direction and a direction of the other end portion of said magnetic tape is arranged to be + Y direction, said light receiving elements Da_1 to Dan are disposed in said - Y direction as well as in a direction in which said magnetic tape runs, said - Y directional end portion of said light receiving element Da_1 is positioned in said - Y direction by the largest degree among said light receiving elements of Da_1 to Da_n, a -Y directional end portion of said light receiving element Da_n is disposed at the n-th order in said - Y direction when said light receiving element Da_1 is arranged as the first light receiving element, and assuming that i represents a positive integer satisfying the relationship $1 \leq i \leq n - 1$, a pitch between a - Y directional end portion of the i-th light receiving device Da_i and a - Y directional end portion of the i + 1-th light receiving device Da_{i+1} is di, and said light receiving devices Da_1 to Da_n hold relative positions $di = d$ when $i \leq 2$ and $di = (i - 2) \times d$ when $3 \leq i \leq n - 1$, and said light receiving elements Da_1 to Da_n are disposed such that an output difference between two of said light receiving elements Da_1 to Da_n due to light emitted from said light emitting means becomes an output from a light receiving element at a tim when said magnetic tape moved to an optional track position with respect to said - Y directional end, and a relation among outputs from said three light receiving elements differs in accordance with each of relative positions between said magn tic tape and said combination head.

6. An apparatus according to claim 5, wher in said light mitting means is disposed at a position confronting said light receiving devices Da_1 to Da_n with said - Y directional nd of said magnetic tape disposed therebetween, and said predetermined relaltion is formed among said three light receiving elements.

7. An apparatus according to claim 1, wherein said combination head is supported between free ends of two parallel leaf springs, one end-portion of one of said parallel leaf springs being secured and the other one end-portion thereof formed said free end.

8. An apparatus according to claim 1, wherein said head operating means includes a voice coil type linear motor, and a magnetic circuit of said voice coil type linear motor is closed in a direction of said combination head and in a direction of said magnetic tape.

9. An apparatus according to claim 8 further includes a movable portion connected to said coil and disposed between said free ends, said movable portion having said combination head and a supporting member for supporting said combination head and capable of synchronizing with a movement of said a coil of said voice coil type linear motor so as to make power of said voice coil type linear motor pass through a portion in the vicinity of the center of gravity of said movable portion.

10. An apparatus according to claim 1 further includes detection means for optically detecting the relative position between said combination head and either one or both of widthwise directional edges of said magnetic tape, and said detecting means outputs a signal which controls a switching operation of said tracks and the relative position between said magnetic tape and said combination head.

11. A magnetic recording/reproducing apparatus of serpentine system capable of recording/reproducing a large amount of high density data at high speed with a tracking control for precisely positioning a combination head, said apparatus comprising:
a combination head having a magnetic head corresponding to a magnetic tape formed by a plurality of tracks arranged in parallel to one another in a direction in which said magnetic tape runs;
a slit formed integrally with said combination head and having openings whose number is the same as the number of a plurality of tracks confronting said magnetic head in said widthwise end portion and said the other end portion of said magn tic tape;
light emitting means disposed in a position confronting one side of said magnetic tape and capable of emitting light through an end portion in a widthwise direction of said magnetic tape;
light receiving means having a plurality of light

receiving elements disposed at a position confronting the other side of said magnetic tape for receiving said light emitted from said light emitting means such that said light receiving means are so disposed that outputs from said light receiving elements have a predetermined relation which governs said feedback control at a time when said magnetic head moved to a predetermined track position; and
head operating means capable of moving said combination head in said widthwise direction of said magnetic tape.

12. An apparatus according to claim 11, wherein said light receiving means is formed independently from said combination head and said light receiving elements are disposed at a position which confronts said opening of said slit plate formed at said end portion, and said opening are placed in parallel with said opening at the other end portion in the widthwise direction of said magnetic tape to one another with said openings in a pair correspond to a predetermined track of said magnetic tape.

13. An apparatus according to claim 12, wherein said slit plate has openings at said end portion and said openings at the other end portion so disposed that outputs from said light receiving elements due to light emitted from said light emitting means via a pair of opening corresponding to said track and to the two widthwise end portions of said magnetic tape establish said predetermined relationship.

14. An apparatus according to claim 11, wherein said light emitting means is disposed at a position confronting said light receiving element via said two widthwise end portions of said magnetic tape and said slit plate.

15. An apparatus according to claim 11, wherein said combination head is supported between free ends of two parallel leaf springs, one end-portion of one of said parallel leaf springs being secured and the other one end-portion thereof formed said free end.

16. An apparatus according to claim 11, wherein said head operating means includes a voice coil type linear motor, and a magnetic circuit of said voice coil type linear motor is closed in a direction of said combination head and in a direction of said magnetic tape.

17. An apparatus according to claim 15 further includes a movable portion connected to said coil and disposed between said free ends, said movable portion having said combination head and a supporting member for supporting said combination head and capabl of synchronizing with a movement of said a coil of said voice coil type linear motor so as to make power of said voice coil type linear motor pass through a portion in the vicinity of the center of gravity of said movable portion.

18. An apparatus according to claim 11 further includes detection means for optically detecting the relative position between said combination head and either one or both of widthwise directional edges of said magnetic tape, and said detecting means outputs a signal which controls a switching operation of said tracks and the relative position between said magnetic tape and said combination head.

19. An apparatus according to claim 11, wherein said combination head disposed at a position confronting said side of said magnetic tape and has a first opening of an opening Sa_2 and a second opening of an opening area Sb_2 which are integrally formed with said combination head.

20. An apparatus according to claim 11, wherein said slit plate disposed said the other side in which said opening area Sa_2 and said opening Sb_2 holds the relationship $Sb_2 \geq n \times Sa_2$, where n represents a positive integer, and said light receiving means formed independently from said combination head is disposed at a position confronting said the other side of said magnetic tape and has a first light receiving element corresponding to said first opening and a second light receiving element corresponding to said second opening.

21. An apparatus according to claim 20, wherein, said first opening and said second opening are disposed to said widthwise end portion of said magnetic tape, and an output Ea_2 from said first light receiving element and an output Eb_2 from said second light receiving element holds the relationship $Eb_2 = m \times Ea_2$ where m represents a positive integer satisfying the relation of $1 \leq m \leq n$ and differring in accordance with each of relative positions between said magnetic head and said plurality of tracks in a range in which said magnetic head can move.

22. An apparatus according to claim 11, wherein, said light emitting means is disposed at a position confronting said first light receiving element and said second light receiving element with said slit plate and said widthwise end portion of said magnetic tape disposed therebetween, and a feedback control of said apparatus is controlled by said first and second openings having a relation of $Eb_2 = m \times Ea_2$ in accordance with said output Ea_2 and said output Eb_2.

23. An apparatus according to claim 11, wherein said slit plate has n pieces of opening A_1 to A_n having the same width in a direction in which said magnetic tape runs on said the other side of said magnetic tape where n represents a positive integer satisfying the relati n of $n \geq 3$, and n pieces of light receiving elements Db_1 to Db_n respectively corresponding to said openings A_1 to A_n are in-

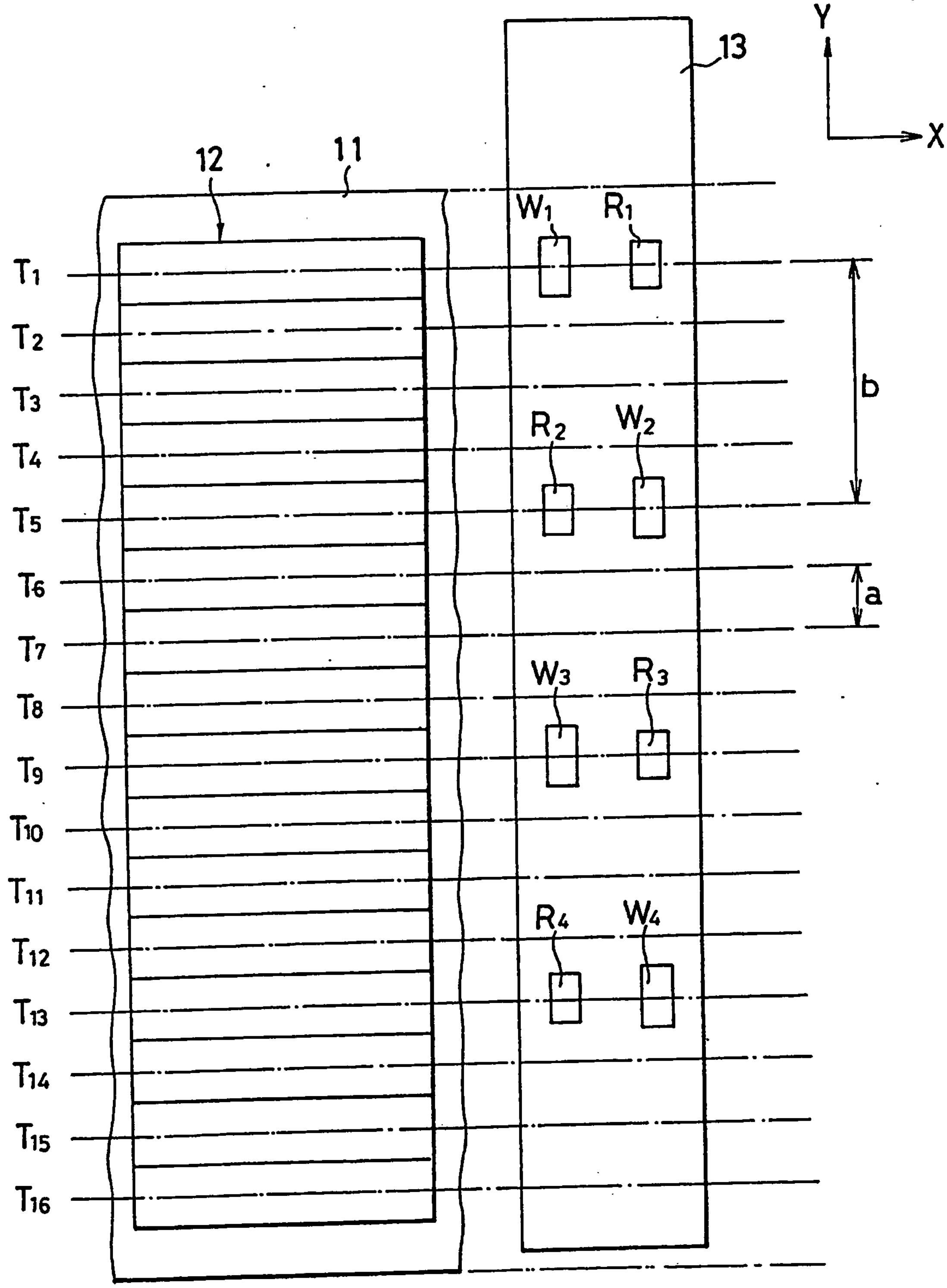
dependently formed with respect to said combination head on said one side of said magnetic tape, a direction of said widthwise end portion of said magnetic tape is arranged to be - Y direction and a direction of the other end portion of said magnetic tape is arranged to be + Y direction, said opening A_1 to A_n are disposed in a - Y direction and in said direction in which said magnetic tape runs when a direction of said widthwise end portion of said magnetic tape is arranged to be - Y direction and a direction of the other end portion of said magnetic tape is arranged to be + Y direction, a - Y directional end portion of said opening A_1 is positioned in the - Y direction by the largest degree among said opening A_1 to A_n, an - Y directional end portion of said openings A_n is disposed at the n-th order in said - Y direction when said opening A_1 is selected as the first opening, assuming that i represents a positive integer satisfying the relation of $1 \leq i \leq n - 1$, a pitch between a - Y directional end portion of the i-th opening A_i and a - Y directional end portion of the - + 1-th opening $A_i + 1$ is di, said openings A_1 to A_n hold the relative positions $di = d$ when $i \leq 2$ and $di = (i - 2) \times d$ when $3 \leq i \leq n - 1$, said openings A_1 to A_n are disposed such that an output difference between two of said light receiving elements Db_1 to Db_n due to light emitted from said light emitting means becomes an output from a light receiving element at a time when said magnetic tape moved to an optional track position with respect to said - Y directional end, and a relation among output from said three light receiving elements differs in according with each of relative positions between said magnetic tape and said combination head.

24. An apparatus according to claim 11, wherein said light emitting means is disposed at a position confronting said light receiving devices Db_1 to Db_n with said - Y directional end of said magnetic tape disposed therebetween, and saids predetemined relation is an output relation among said three light receiving elements due to light emitted from said light emitting means via said - Y directional end of said magnetic tape and said openings A_1 to A_n.

25. A magnetic recording/reproducing apparatus in which the position of a composite recording head relative to a magnetic recording tape in a widthwise direction of the tape is variable for multiple-track operation, and in which a feedback tracking control means is provided for establishing and maintaining a required said relative position, said tracking control means being arranged to detect optically at least one dge of th tape.

26. A magnetic recording/reproducing apparatus according to claim 25 wherein said tracking control means includes a light source and a light detector means arranged on respective opposite sides of the tape so that light reception by the light detector means varies as said relative position varies.

Fig. 1



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11
W1
R1
T1
T2
T3
T4
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T6
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T9
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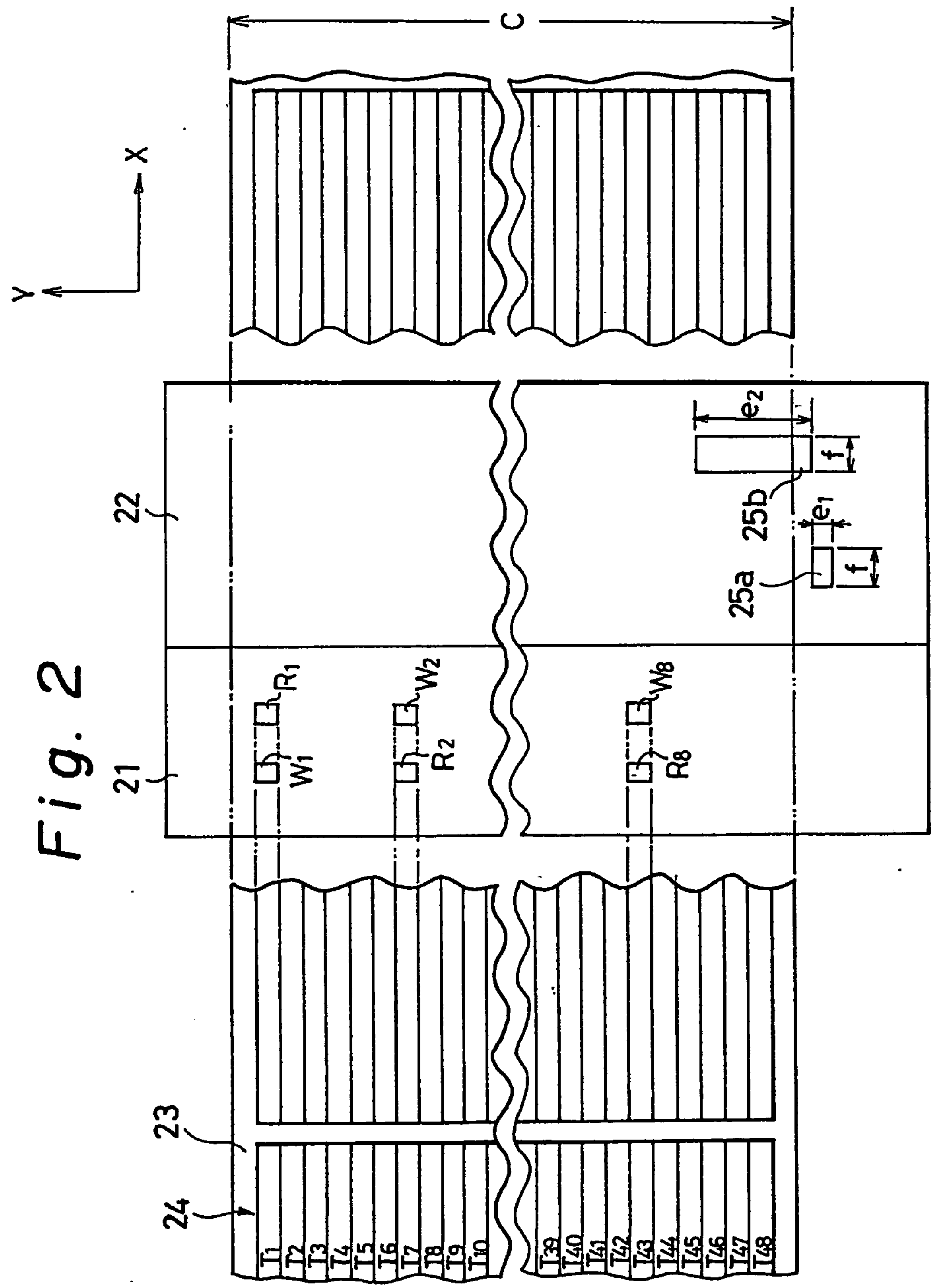
R3
R4
W4

Fig. 2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T5
T6
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T46
T47
T48

Fig. 3a

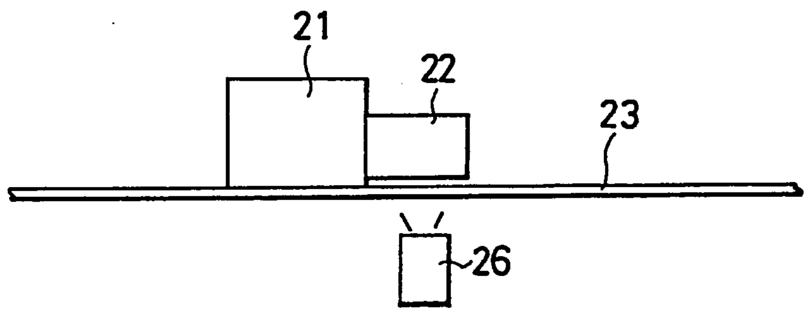

Fig. 3b

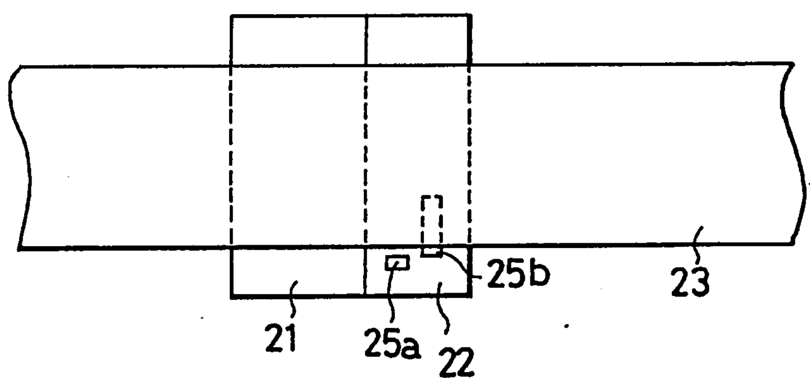

Fig. 4

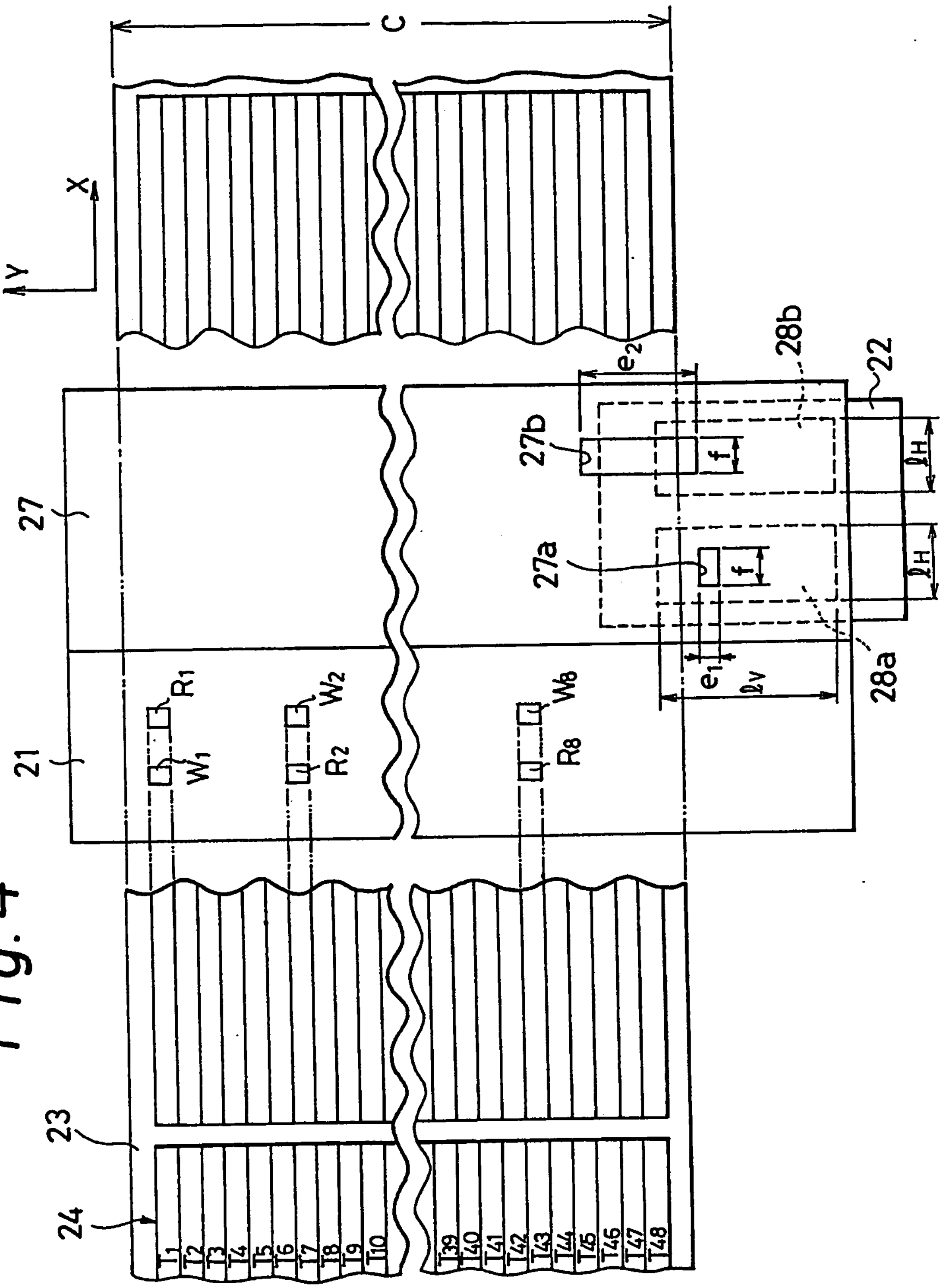
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Fig. 5a

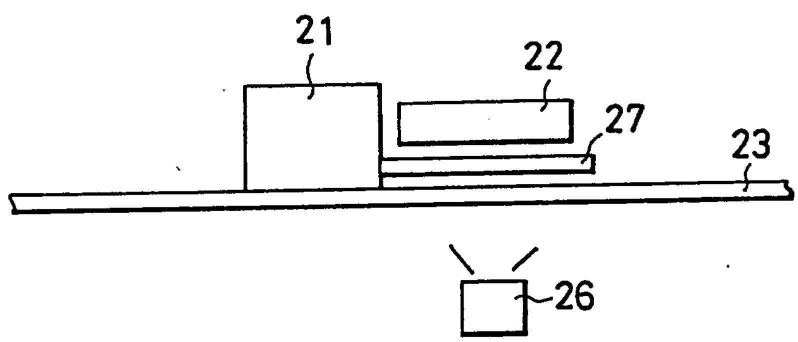


Fig. 5b

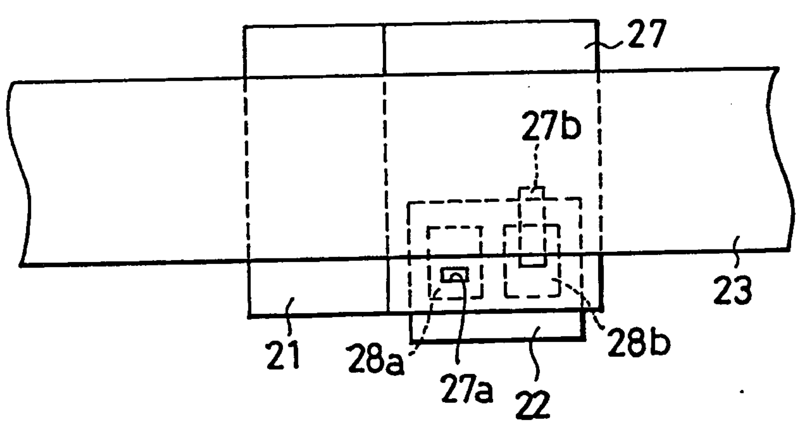
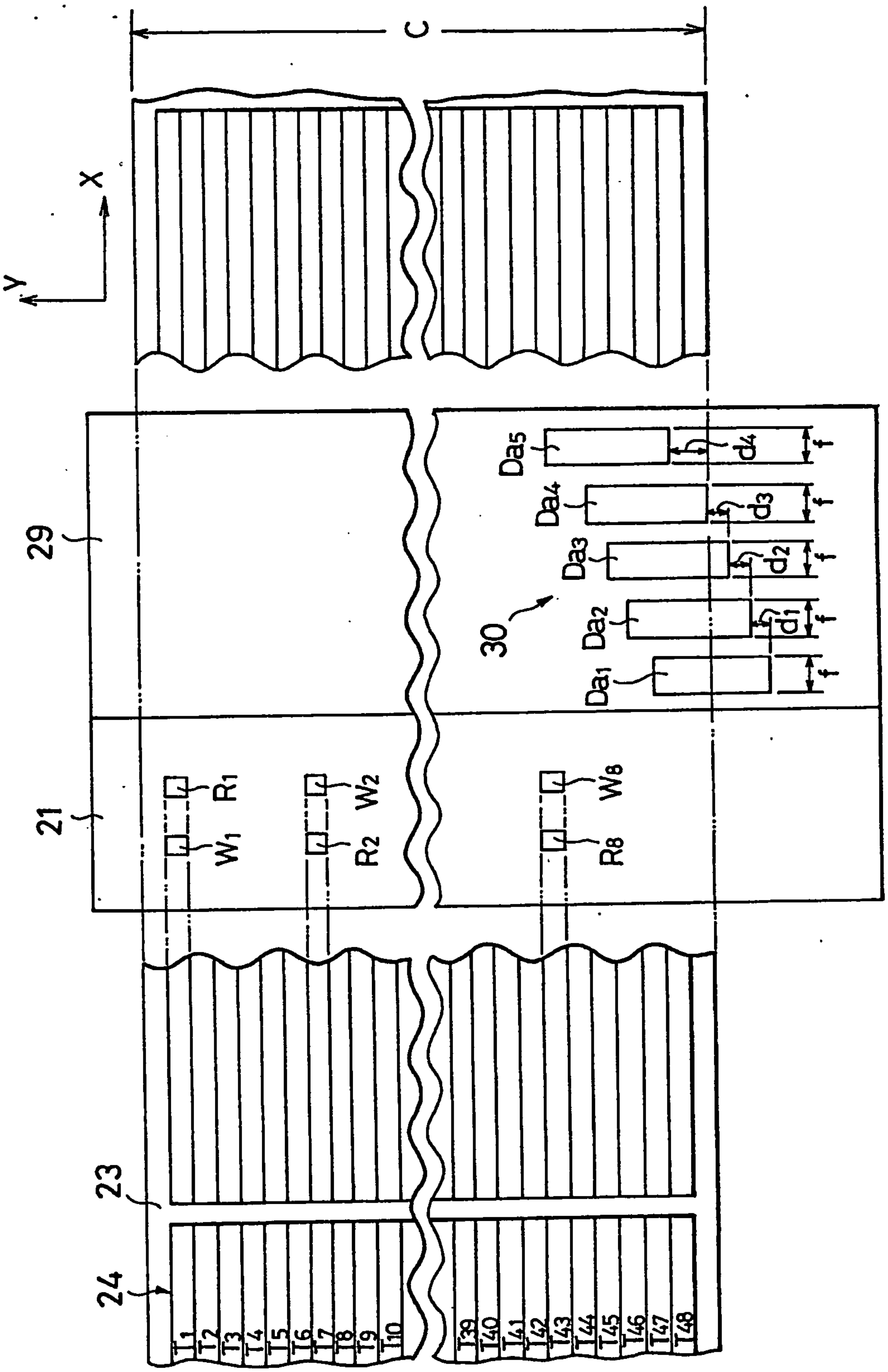


Fig. 6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R1
R2
W2
R8
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T5
T6
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T48

Fig. 7a

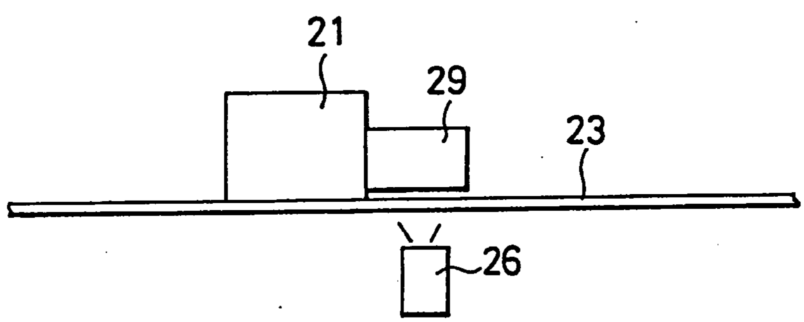


Fig. 7b

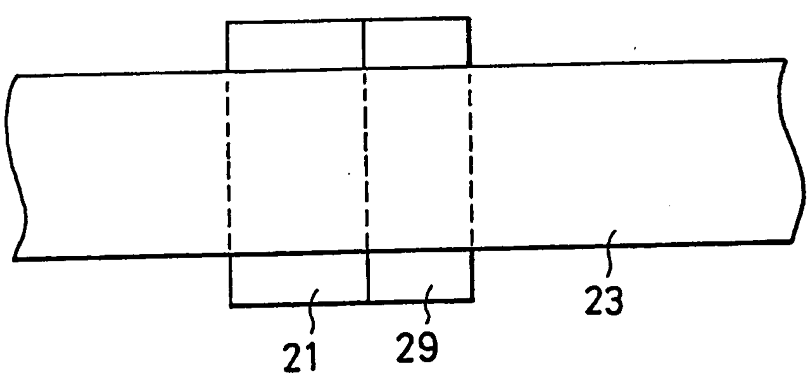
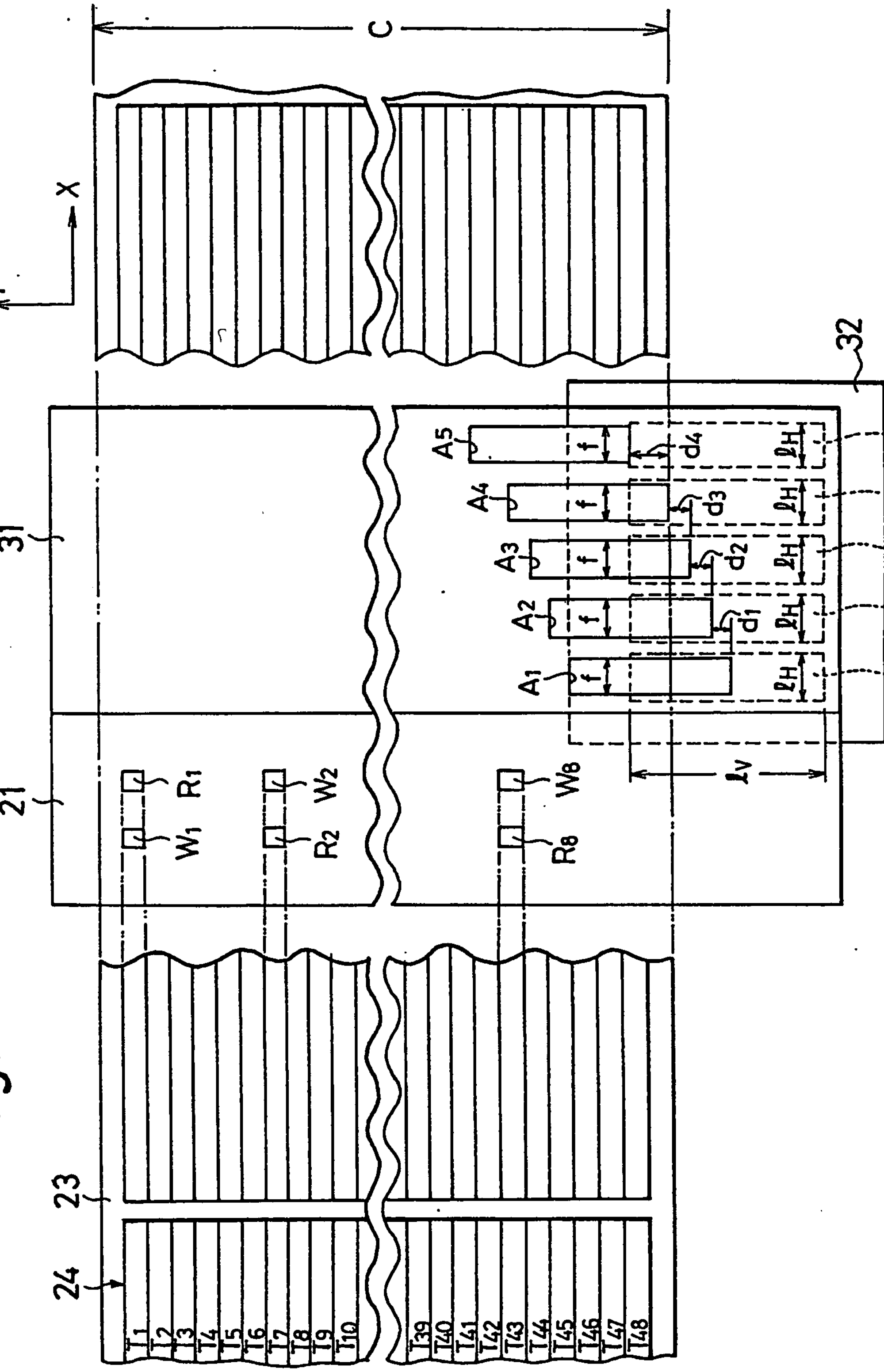


Fig. 8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Db1
Db2
Db3
Db4
Db5
W1
R1
R2
W2
R8
W8
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24
T1 T2 T3 T4 T5 T6 T7 T8 T9 T10
T39 T40 T41 T42 T43 T44 T45 T46 T47 T48

Fig. 9a

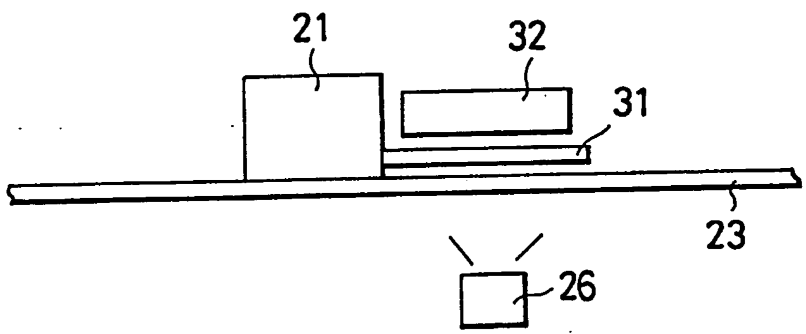
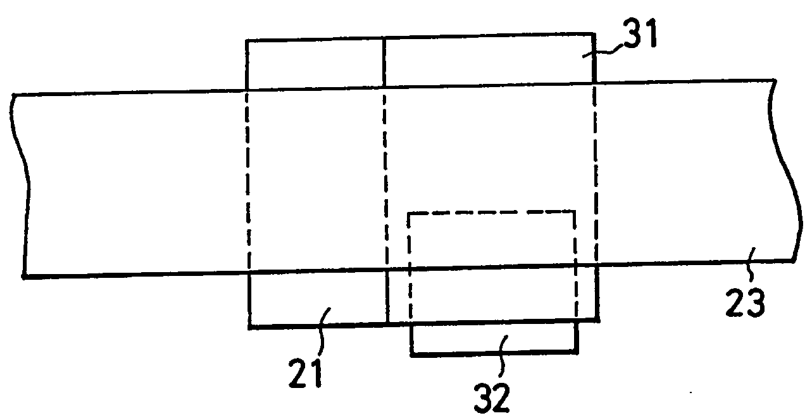
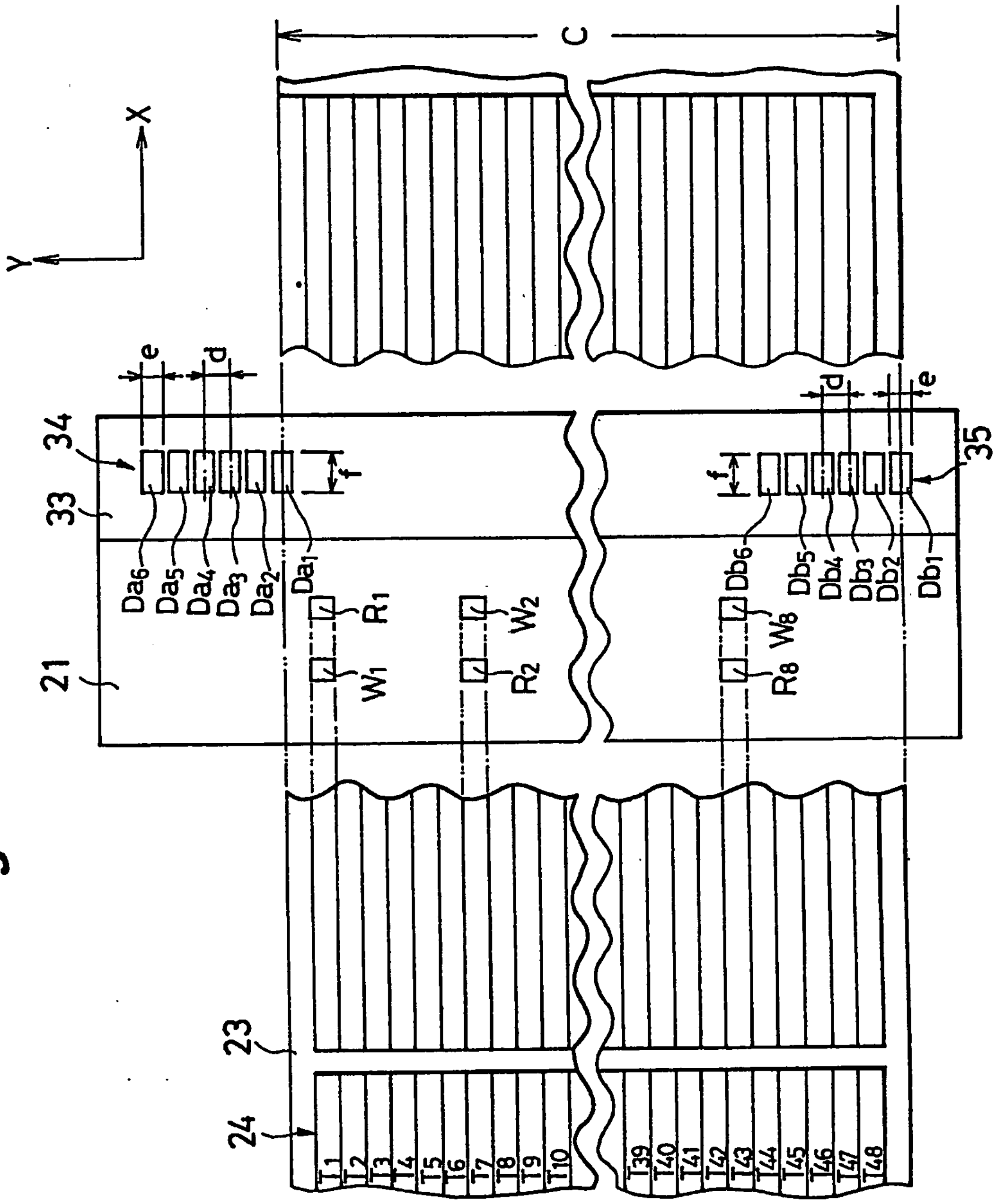


Fig. 9b

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T48

Fig. 10

Fig. 11a

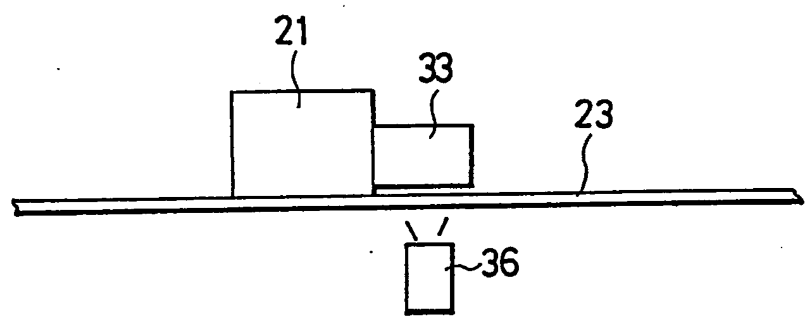
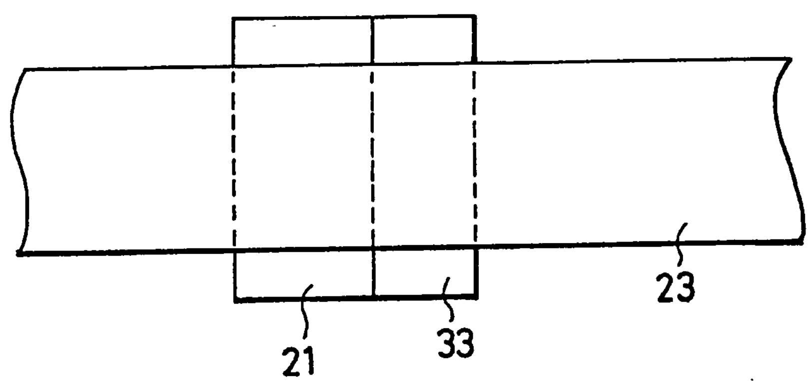
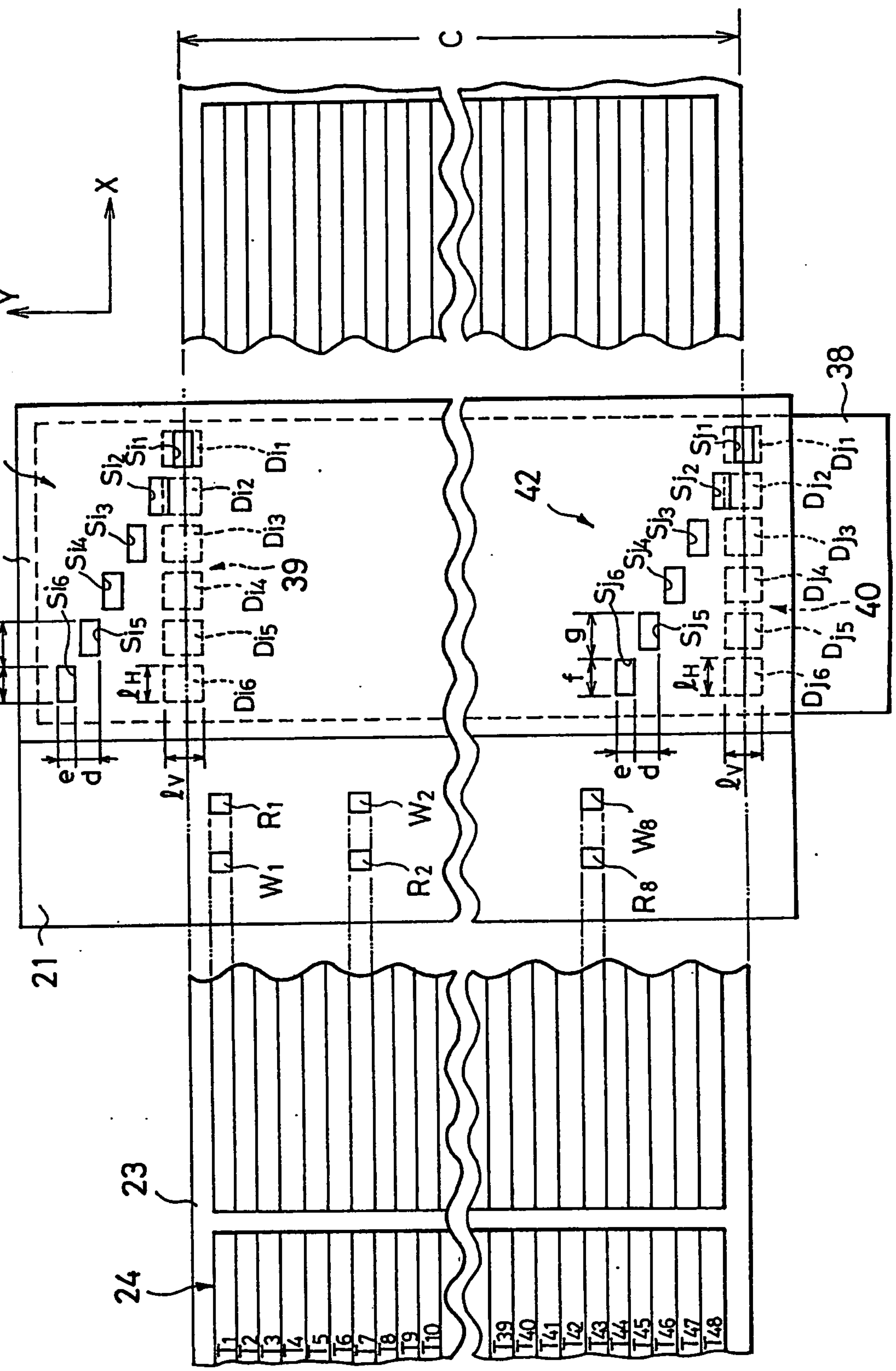


Fig. 11b





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T7
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T10
T39
T40
T41
T42
T43
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T46
T47
T48

Fig. 12

Fig. 13a

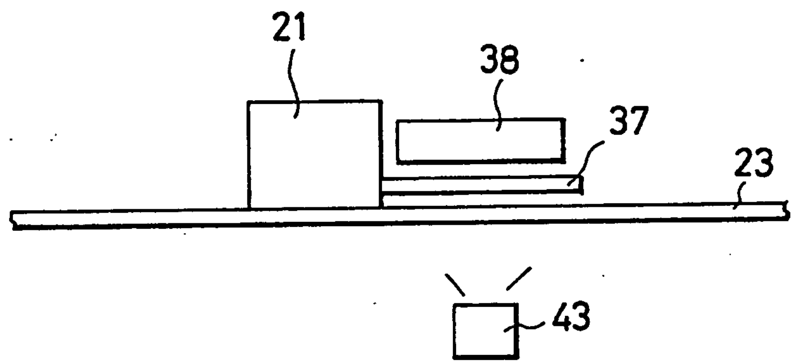


Fig. 13b

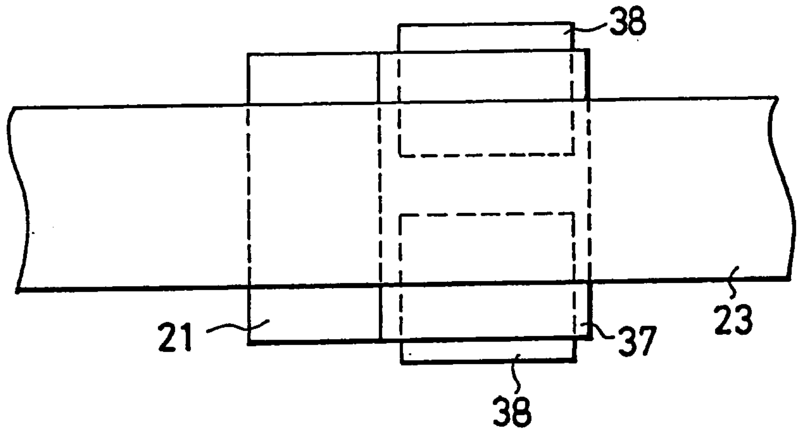


Fig. 14

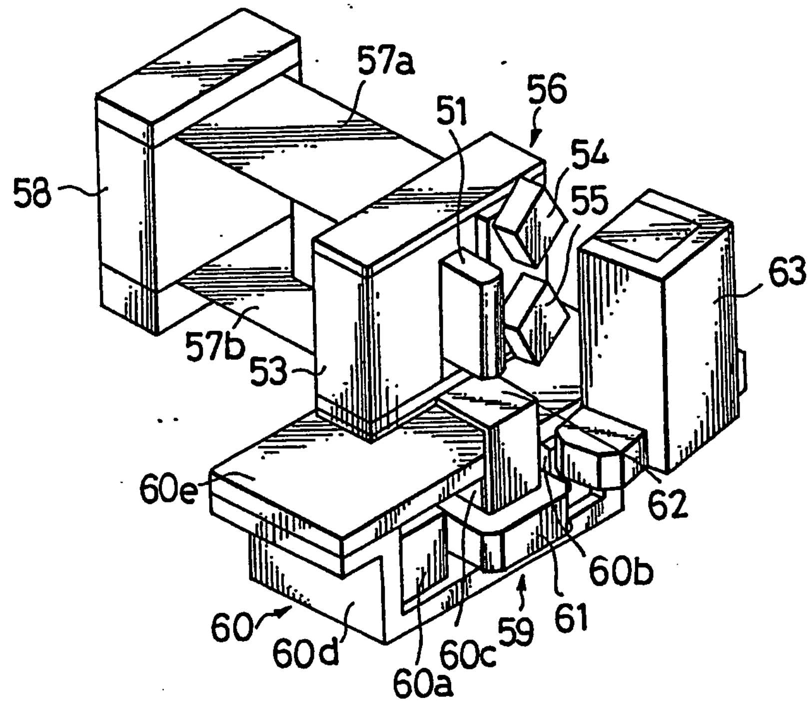
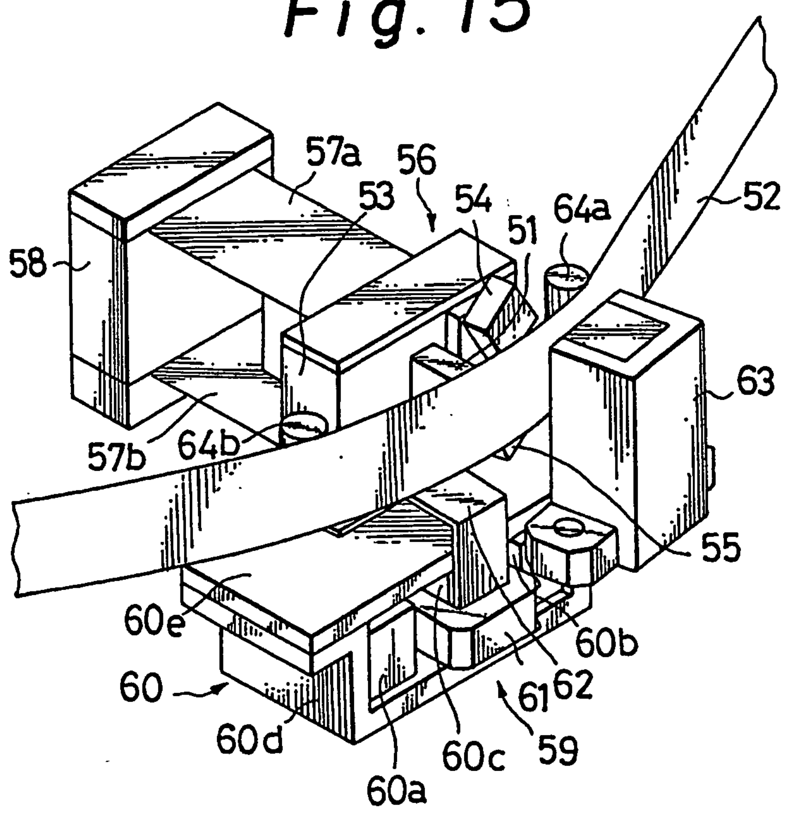

57a
56
51
54
55
58
63
57b
53
60e
62
60b
61
60
59
60d
60c
60a

Fig. 15


57a
56
53
54
51
64a
52
58
63
57b
64b
55
60e
60b
62
60
61
60d
60c
59
60a

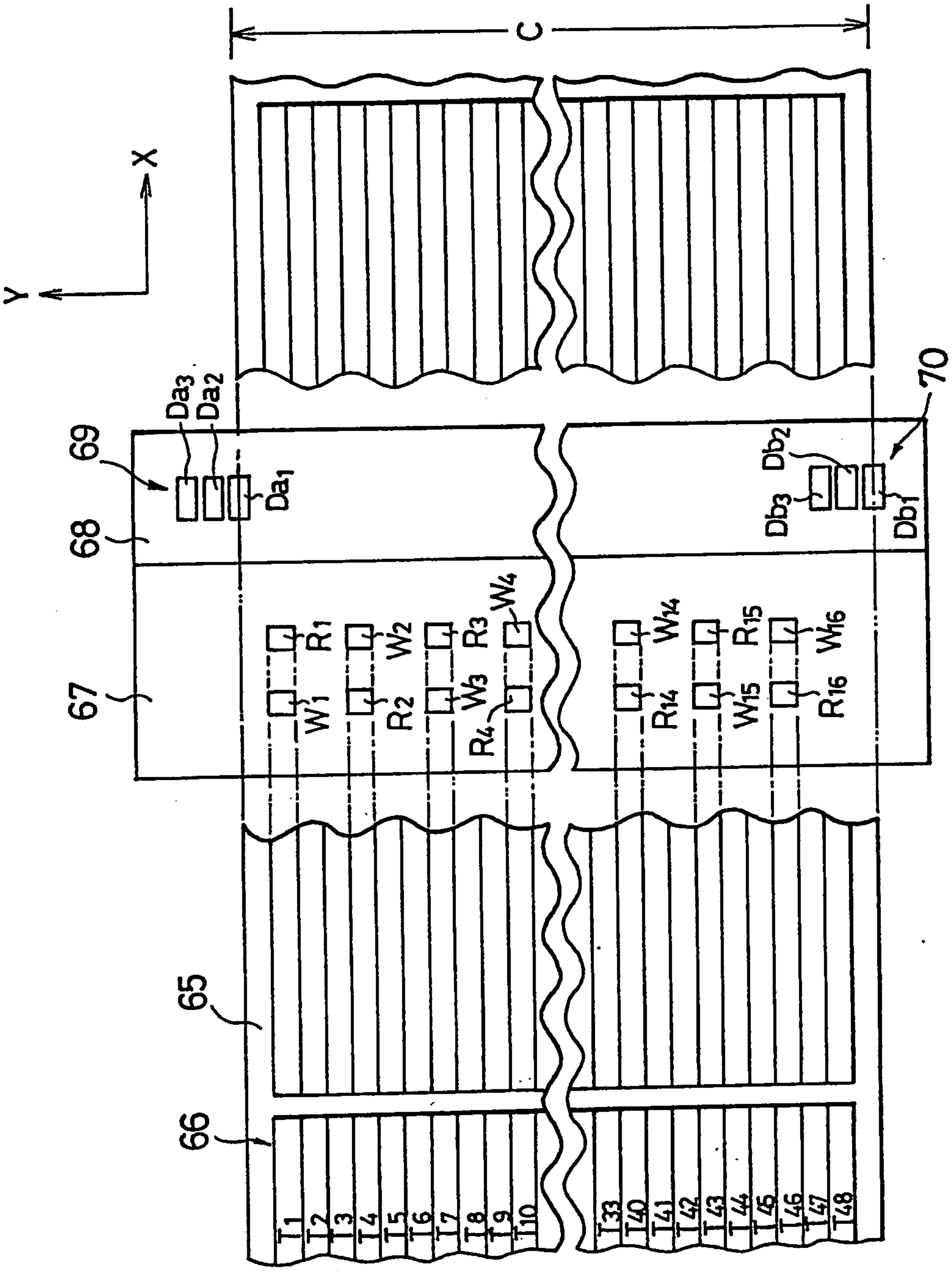
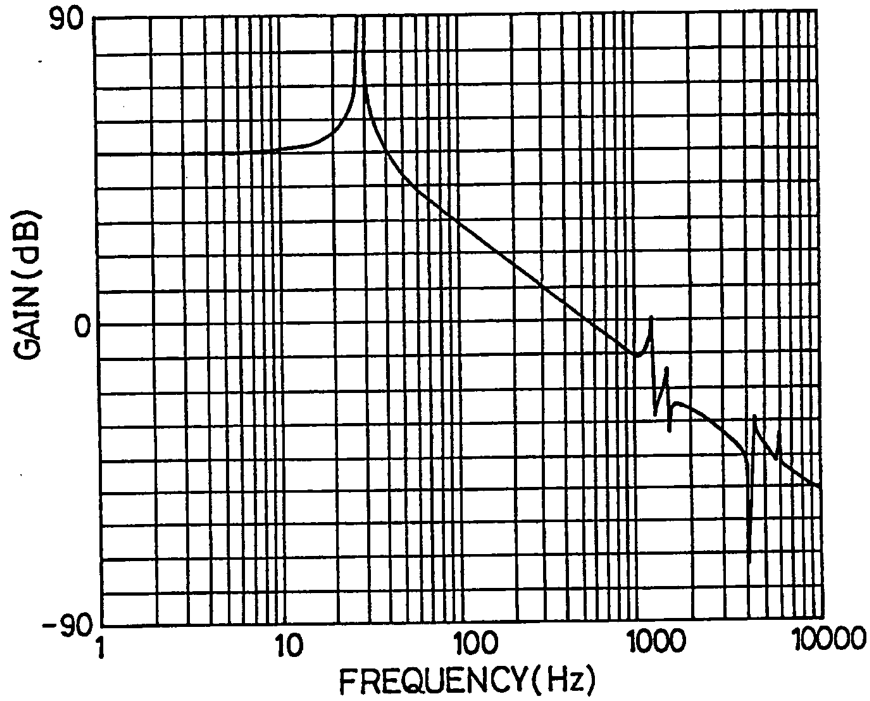

C
X
Y
69
68
67
65
66
70
Da1
Da2
Da3
Db1
Db2
Db3
W1
R1
R2
W2
W3
R3
R4
W4
R14
W14
W15
R15
R16
W16
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
T33
T40
T41
T42
T43
T44
T45
T46
T47
T48

Fig. 16

Fig. 17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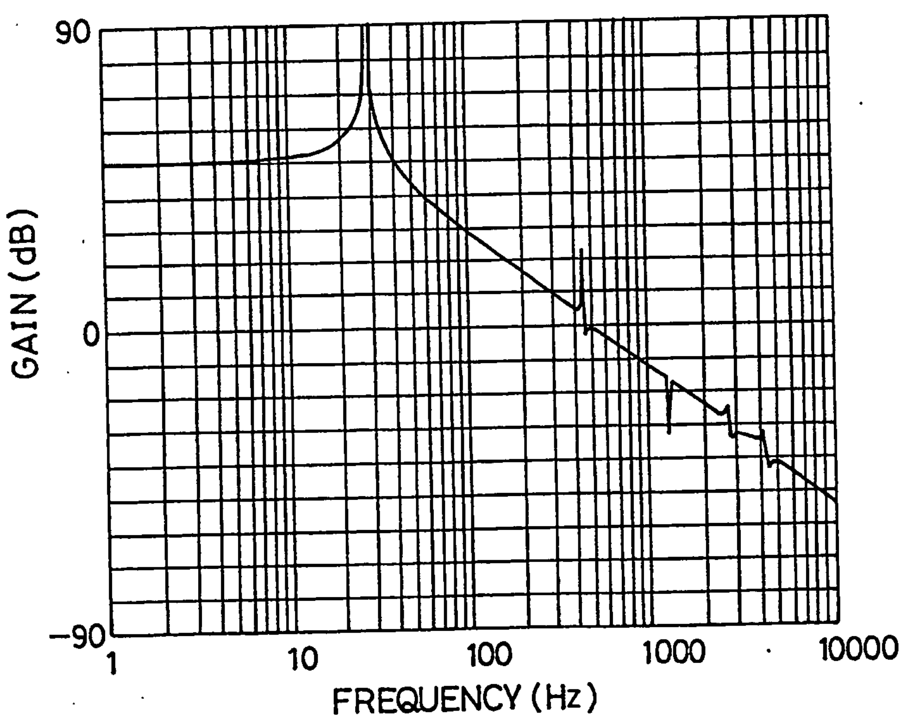
0
-90
GAIN (dB)
1
10
100
1000
10000
FREQUENCY (Hz)

Fig. 18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GAIN (dB)
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10
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1000
10000
FREQUENCY (Hz)

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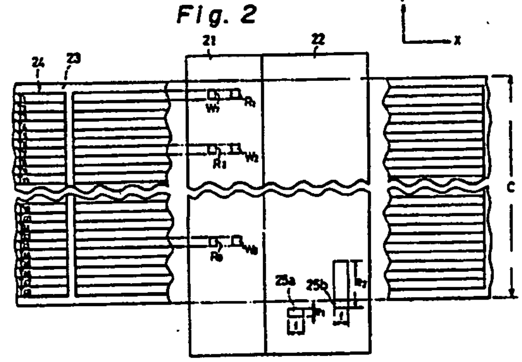
(54) **Magnetic recording/reproducing apparatus.**

(57) A magnetic recording/reproducing apparatus of serpentine system capable of recording/reproducing a large amount of high density data at high speed with a tracking control for precisely positioning a combination head includes a combination head having a magnetic head corresponding to a magnetic tape formed by a plurality of tracks arranged in parallel to one another in a direction in which the magnetic tape runs, and a light emitting unit disposed at a position confronting one side of the magnetic tape for emitting light in a widthwise direction of the magnetic tape. The appratus also includes a light receiving unit having a plurality of light receiving elements disposed at a position confronting the other side of the magnetic tape for receiving the light emitted from the light emitting unit such that the light receiving unit are so disposed that outputs from the light receiving elements have a predetermined relation which governs the feedback control at a tim when the magnetic head moved to a predetermined track position, and a head operating unit capable of moving the combination head in the widthwise direction of the magnetic tape. The apparatus further has a slit plate formed integrally with the combination head and having openings whose number is the same as the number of a plurality of tracks confronting the magnetic head in the widthwise end portion and the the other end portion of the magnetic tape.

Fig. 2



EP 0 390 555 A3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 90303355.3

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	EP - A1 - 0 026 524 (N.U. PHILIPS' GLOEILAMPEN-FABRIEKEN) * Fig. 1-4; claims 1-7 * ----	1,3,7 25,26	G 11 B 5/55 G 11 B 23/18
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			G 11 B 5/00 G 11 B 23/00 G 11 B 21/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	08-08-1990	BERGER

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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EP 0 390 555 B1

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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a multi-track magnetic recording/reproducing apparatus which uses a magnetic tape having a reduced width as a recording medium. More particularly, the present invention relates to a magnetic recording/reproducing apparatus capable of precisely recording/reproducing a large amount of data at high speed and the precise recording/reproducing being performed with a precise tracking control maintained.

2. Description of the Related Art

The inventors know that a magnetic recording/reproducing apparatus, except the one having a rotary head, used for an audio device has the same numbers of the tracks and the recording heads or the same numbers of the reproducing heads and the recording heads in pairs. The above-described term "the number of the tracks" means the total number of data tracks formed in parallel to the direction in which the tape runs. The magnetic recording/reproducing apparatus of the above described type includes a device for restricting the relative positions between the magnetic tape and the magnetic head. The restricting device has generally a guide post or the like, having a pair of flanges for guiding the two vertical ends of the magnetic tape so as to make it run toward the fixed magnetic head, is formed in a passage through which the magnetic tape runs. Thus, the vertical movement of the magnetic tape is restricted.

On the other hand, a multi-track magnetic recording/reproducing apparatus used for a backup storage of an information processing system, so-called "a cassette streamer", employs a recording/reproducing system known as "a serpentine system". A conventional serpentine system has a pair of a recording head for recording and a reproducing head for reproducing the contents when a magnetic tape is run in one direction and another pair of a recording head for recording and a reproducing head for reproducing the contents when the magnetic tape is run in the other direction so that it is capable of corresponding to a plurality of tracks. In this system, information is successively recorded or reproduced from tracks during the running of the magnetic tape in one direction or in the other direction instead of recording information on a plurality of tracks of the magnetic tape simultaneously. At th time of the above-described operation, th tracks are switched by m ving the above-described two pairs of the r cording heads and the reproducing heads, and the positioning of th magnetic tap to th positi n of a desir d track is simultaneously perform d. Ther is a known device for restricting the relative positions betwe n th head and the magnetic tape as disclosed in JP-A-62-183019 in which th positioning of th head is achi ved in accordance with an open loop control method with a stepping motor provided in which the restricting flanges are used in addition to the above-described structure.

Recently, a combination head having multiple heads has been developed in accordance with an advancement of a thin film magnetic head. Therefore, multi-track magnetic recording/reproducing apparatus enabling higher density storage have been developed. The apparatus of the type described above is capable of recording information in a narrow track width, reducing the allowable offtrack distance.Therefore, in order to operate a precise tracking control, the device for restricting the relative positions between the tape and the head has an additional structure which followup-controls the magnetic head with respect to the waving movement of the magnetic tape. The added structure is a head moving device for moving the magnetic head in the widthwise direction of a tape in addition to the above-described mechanism in which the flanges are provided for the purpose of restricting the vertical movement of the magnetic tape.

The apparatus of the type described above is exemplified by a fixed-head digital audio tape recorder which has the same numbers of the recording heads and the tracks or the same numbers of the reproducing heads each of which forms a pair with the above-described recording heads and the tracks. The apparatus of the type described above is arranged, as disclosed in the Trans. IECE Japan EA83-56, Trans. IECE Japan EA81-64 and the Sharp Engineering Report 1984-28, a servo-only track formed on the magnetic tape is traced by two parallel reproducing heads disposed in the widthwise direction of the tape so as to compare and followup-control the reproduction output therefrom for restricting the relative positions between the magnetic head and the magnetic tape.

Another device for restricting the relative positions between the tape and the head has been disclosed in Japanese Patent Publication No. 63-64811 in which a structure for magnetically detecting the relative positions between an end portion of the magnetic tape and the magnetic head is provided for a magnetic recording/reproducing apparatus arranged to have the same number of the heads and the tracks.

However, the device for restricting the relative positions between the tape and the head has a guide post having flanges which restrict the vertical movement of the magnetic tape by contacting the vertical ends f th magn tic tape with the flanges of the guide post. Therefore, if a magnetic tape having a width which is larger than th distance betw en the upper flange and the lower flange is driven, the mechanical stresses act upon the two vertical ends of the

magnetic tap and cause th two vertical ends of th magnetic tap to be damaged. Therefore, the restriction width in th above-d scribed restricting device is limited to several tens of µm, because th nd portions of the magnetic tape must be protected from the damage. Consequently, in a high density magnetic recording/reproducing apparatus in which the allowable offtrack is arranged in the range from ten and several µm to several tens of µm, the above-described structure in which the movement of the magnetic tape is restricted by the flanges or the like cannot correspond to the above-described allowable offtrack.

When a higher recording density is desired, the width of the track of the magnetic tape can be reduced by reducing the width of the track of the magnetic head. However, the reduction in the track pitch involves a certain limit since the integration of the thin film head is limited to a certain degree. Furthermore, an increase in the number of the heads causes the size of the circuit to be enlarged and the overall cost is thereby risen. Therefore, a high density magnetic recording/reproducing apparatus which is provided with the pitch of the tracks is several tens of µm and the several tens to hundreds of tracks cannot employ the same number of the heads and the tracks.

On the other hand, the multi-track magnetic recording/reproducing apparatus so-called a cassette streamer and employing the conventional serpentine system is arranged to record/reproduce information on the multiplicity of the tracks by moving the magnetic head in the widthwise direction of the magnetic tape. Therefore, the recording/reproducing can be operated by moving the magnetic head in several times even if the track pitch is reduced and the number of the tracks is increased. Therefore, the integration of the thin film head does not encounter a problem.

However, the track width necessarily becomes several tens of µm when the track pitch is made several tens of µm. Therefore, the allowable offtrack also becomes ten and several µm to several tens of µm. It leads a fact that the device for restricting the relative positions between the tape and the head, in which the restriction by means of the flanges or the like and the open loop control by using the stepping motor are performed, does not correspond to the above-described allowable offtrack.

It might therefore be considered feasible to employ a structure for overcoming the above-described problem in terms of the allowable offtrack, the structure being arranged such that the relative positions between the magnetic head and the magnetic tape is detected by a sensor and the head operating device is f ed-back controlled by a det ction signal so that th magnetic head is tracking-controlled.

How v r, if the above-described tracking c ntrol of sev ral µm is d sired to be achieved, a m chanism for supporting th magn tic h ad, a power source for th magnetic head, a mechanism for transmitting power to the magnetic head, and a sensor for d t cting th r lativ positions betw en th magn tic tap and the magnetic head must b constituted pr cisely. However, the conventional head operating device has a complicated structure and a large dead zone since it includes the power source utilizing a rotary motor such as the stepping motor, a mechanism for converting the rotational motion of the rotary motor into a linear motion, a bearing supporting mechanism and the like. Therefore, a desired control accuracy cannot be obtained. Furthermore, since a mechanism for supporting the magnetic head by means of parallel leaf springs is employed in the conventional structure, a feedback control with an excellent gain cannot be obtained easily due to an influence of the secondary resonance. The secondary resonance takes place because the magnetic head is secured to either of the leaf springs or because the mechanism for supporting the magnetic head is connected to the above-described mechanism for converting the rotational motion of the power source for the magnetic head into the linear motion.

Furthermore, if the tracking control by means of the servo track of the type employed in the above-described fixed-head digital audio tape recorder is operated in accordance with the serpentine method, a multi-servo tracks must be provided and problems in terms of a recording density on the servo track arise. Therefore, even if the method of this type is employed, high density recording cannot be obtained satisfactorily.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a magnetic recording/reproducing apparatus system capable of recording/reproducing a large amount of high density data at high speed with a tracking control for precisely positioning a combination head. The apparatus of the present invention is capable of recording/reproducing the data without providing flanges for restricting the relative positions between the magnetic tape and the magnetic head and without a servo track on the magnetic tape.

Accordingly the invention provides a magnetic recording/reproducing apparatus comprising a composite magnetic head having a number of recording/reproducing heads less than the number of tracks provided on a magnetic tape in parallel with each other and with the direction (X) in which the tape runs, said composite head being movable relative to the magnetic tape in the widthwise direction (Y) of the tape to a number of p rational positi ns at each of which said heads are aligned with a respective set f desired nes of said tracks, characteris d by control m ans f r s tting and maintaining said composite head at a selected on of said positions, said control

means including an ptical system having a light mitting m ans and a multi-elem nt light r ceiving means disposed on opposit sides of th tape, and arranged to transmit light past at least on edge of the tape in such a way that the pattern of light transmitted to said multi-element light receiving means is dependent upon said operational position of the composite head relative to the tape.

According to a first embodiment the light receiving means comprises first and second light receiving elements which are arranged so that the output of the second light receiving element is a multiple of the output of the first light element and dependent upon the operational position of the composite magnetic head. Preferably in each operational position of the composite magnetic head a constant area of said first light receiving element is exposed to light from said light emitting means whilst the area of the second light receiving element exposed to light from the light emitting means varies in dependence upon the operational position of the composite magnetic head. In a preferred embodiment the quantity of light received by the second light receiving element in each operational position of the composite magnetic head is an integer multiple of the light received by the first element, where the integer multiple corresponds to the respective operational position.

In one aspect of the first embodiment the light receiving means is mounted to and movable with the composite magnetic head. In a second aspect a slit plate is mounted to the composite magnetic head and is movable therewith, the slit plate being movable between the light emitting means and the light receiving means and having aperture means therein which controls the pattern of light transmitted to the first and second light receiving elements in dependence upon the operational position of the composite magnetic head. According to this second aspect of the first embodiment the aperture means may comprise a first aperture allowing a constant area of the first light receiving element to be illuminated by the light emitting means and a second aperture illuminating an area of the second element in dependence upon the operational position of the composite magnetic head.

According to a second embodiment a plurality of spaced apart light receiving elements may be provided adjacent an edge of the tape, the arrangement being such that outputs of selected ones of said light receiving elements have predetermined relationships in each of the operational positions. Preferably for each operational position the output of a selected light receiving element equals the sum of the output of two other selected light receiving elements.

According to a first aspect of the second emb diment the light r c iving elem nts are mounted to and m vable with th composit magnetic head. Preferably the light rec iving el ments are in operati n displaced by differing amounts from an edge f the tap .

The pitch d_i between th nds of adjacent light receiving lem nts Da_i, Da_{i+1} in th lateral dir ction to the tap is preferably det rmined according to:

$$d_i = d \text{ wh n } i \leqq 2$$

and

$$d_i = (i - 2)\, d \text{ when } 3 \leqq i \leqq n - 1$$

where d is the pitch of the tracks on the magnetic tape and n is the number of light receiving elements.

According to a second aspect of the second embodiment a slit plate is mounted to the composite magnetic head and movable therewith, the slit plate being movable between the light emitting means and the light receiving means and having aperture means which selectively allows light to pass from the light emitting means to selected ones of the light receiving elements in a pattern dependent upon the operating position of the composite magnetic head. Preferably the aperture means comprises a plurality of slits wherein each slit is arranged to allow light to pass from the light emitting means to a respective light receiving element and selected ones of the operational positions of the composite magnetic head. The pitch d_i between the ends of adjacent slits A_i and A_{i+1} of the slit plate in the lateral direction of the magnetic tape is preferably determined according to

$$d_i = d \text{ when } i \leqq 2$$

and

$$d_i = (i - 2)\, d \text{ when } 3 \leqq i \leqq n - 1$$

where d is the pitch of the tracks on the magnetic tape and n is the number of slits.

According to a third embodiment a plurality of light receiving elements are provided adjacent each edge of the magnetic tape. The number of light receiving elements adjacent each edge of the tape is preferably equal to the number of operational positions. The pairs of light receiving elements are preferably arranged with one element of each pair adjacent each edge of the magnetic tape, the arrangement being such that the outputs of each pair of light receiving elements satisfy a predetermined relationship when the composite magnetic head is in a respect one of the operational positions. Preferably the predetermined relationship is that the outputs of the light receiving elements of a pair of light receiving elements are balanced.

According to a first aspect of the third embodiment the light receiving means is mounted to the composite magnetic head and movable therewith, the light receiving elements being positioned so that light receiving elements of respective pairs of light receiving elements are substantially aligned with respective edges of the magnetic tape in each respective operational position.

According to a second aspect of the third mbodiment a slit plat is mount d t th composite magnetic head and movable between the light mitting means and the light receiving means having aperture

means therein which allows light t pass through respective pairs of light emitting l m nts in ach respective operational position. Pr f rably th light rec iving elements ar arranged along the dg s of the magnetic tape and the aperture means comprises a plurality of apertures which permit light to pass to a respective pair of light receiving elements in each respective operational position.

The composite magnetic head of the foregoing embodiments is preferably supported between free ends of two parallel leaf springs. The control means preferably includes a voice coil type linear motor for setting and maintaining the composite head at a selected one of the operational positions. The voice coil type linear motor preferably has a magnetic circuit which is closed in the direction of the composite magnetic head and in the direction of the magnetic tape. Preferably the composite magnetic head is mounted on a support means which is disposed between the free ends of the parallel leaf springs. The support means being responsive to movement of the coil of the voice coil type linear motor to set and maintain the operational position of the composite magnetic head. The voice coil is preferably connected to the support means in such a manner that force from the voice coil is applied in the vicinity of the centre of gravity of the support means.

The light receiving elements may be manufactured using semiconductor technology to enable the composite magnetic head to be positioned with sufficient accuracy. The apertures of the slit plates may be produced using etching technology to ensure that sufficient accuracy is achieved.

The use of a voice coil type linear motor overcomes the dead zone and frictional load problems previously encountered. The leakage flux from the voice coil type linear motor is reduced by closing the magnetic circuit of the voice coil type linear motor in the direction of the combination head and the magnetic tape.

The composite magnetic head is preferably mounted to a support member which is disposed between the free ends of two parallel leaf springs. The voice coil type linear motor is arranged to transmit force to the support member in the vicinity of the centre of gravity thereof. This arrangement allows a reduction of secondary resonance and increases the precision of the servo control.

The optical system of the invention enables the combination head to be accurately positioned without the need for a servo track. Furthermore, the arrangement of light receiving elements ensures that the system is temperature compensated.

The recording/reproducing apparatus of the invention nables a composite magnetic head to be accurately positi n d on th magnetic tape to all w a large amount of data t be recorded at high sp ed. The apparatus is particularly suitabl for use in a serpentin type system.

Th pr s nt invention will be apparent from th following d scription of th pref rred embodim nts of th invention as illustrated in th accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic front elevational view of the magnetic tape and the combination head for a magnetic recording/reproducing apparatus according to the present invention:

Fig. 2 is a front elevational view which illustrates the relative positions among a magnetic tape, a combination head and a light receiving device;

Fig. 3a is a schematic plan view which illustrates the relative positions among the magnetic tape, the combination head and the light-receiving device;

Fig. 3b is a front elevational view which illustrates the relative positions among the magnetic tape, the combination head and the light-receiving device;

Fig. 4 is a front elevational view which illustrates the relative positions among the magnetic tape, the light receiving device of the combination head, the reference opening and an opening for detecting the positional relationship;

Fig. 5a is a schematic plan view which illustrates the relative positions among the magnetic tape, the combination head, a light-receiving device and a slit plate;

Fig. 5b is a front elevational view which illustrates the relative positions among the magnetic tape, the combination head, a light-receiving device and a slit plate;

Fig. 6 is a front elevational view which illustrates the relative positions among the magnetic tape, the combination head and the light receiving device;

Fig. 7a is a schematic plan view which illustrates the relative positions among the magnetic tape, the combination head and the light-receiving device;

Fig. 7b is a front elevational view which illustrates the relative positions among the magnetic tape, the combination head and the light-receiving device;

Fig. 8 is a front elevational view which illustrates the relative positions among the magnetic tape, the combination head, the light receiving device and openings formed in the slit plate;

Fig. 9a is a schematic plan view which illustrates the relative positions among the magnetic tape, the combination head, the light-receiving device h lding m mber and the slit plate;

Fig. 9b is a front el vational view which illustrates the relative p siti ns am ng the magnetic tap ,

the combination head, the light-receiving device holding member and the slit plate;

Fig. 10 is a front elevational view which illustrates the relative positions among the magnetic tape, the combination head and the light receiving device;

Fig. 11a is a schematic plan view which illustrates the relative positions among the magnetic tape, the combination head and the light-receiving device holding member;

Fig. 11b is a front elevational view which illustrates the relative positions among the magnetic tape, the combination head and the light-receiving device holding member;

Fig. 12 is a front elevational view which illustrates the relative positions among the magnetic tape, the combination head, the light-receiving device and openings formed in the slit plate;

Fig. 13a is a schematic plan view which illustrates the relative positions among the magnetic tape, the combination head, the light-receiving device holding member and the slit plate;

Fig. 13b is a front elevational view which illustrates the relative positions among the magnetic tape, the combination head, the light-receiving device holding member and the slit plate;

Fig. 14 is a perspective view which illustrates the magnetic tape in non-loaded state;

Fig. 15 is a perspective view which illustrates the magnetic tape in loaded state;

Fig. 16 illustrates the structure of a tracking control;

Fig. 17 illustrates the transfer function of the spring system of the parallel leaf spring supporting structure shown in Figs. 14 and 15; and

Fig. 18 illustrates the transfer function of the spring system when the combination head and the holder are not disposed between the parallel leaf springs with the axis of abscissa representing frequencies and the axis of ordinate representing gains.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A first embodiment of the present invention will now be described with reference to Figs. 1 to 3.

A magnetic recording/reproducing apparatus according to the present invention is suitable for recording and reproducing data in accordance with a serpentine method in which magnetic heads whose number is smaller than the number of the tracks of the magnetic tape used. First, the serpentine method which is used for the recording/reproducing apparatus according to the present invention will be described with reference to Fig. 1. Referring to Fig. 1, it is assumed that the direction in which a magnetic tape 11 runs is X and that the widthwise direction of the magnetic tape 11 is Y. A track group 12 is formed on the magnetic tape 11, the track group 12 having 16 tracks T_1 to T_{16} in the direction Y at the same pitch a. A combination head 13 has four recording heads W_1 to W_4 and reproducing heads R_1 to R_4 which are integrally formed and disposed so as to correspond to the above-described track group 12. The recording heads W_1 to W_4 are in parallel provided in the direction Y at the same pitch b (b = 4a), while the reproducing heads R_1 to R_4 are disposed in parallel in direction X or - X in such a manner that they form pairs with the corresponding recording heads W_1 to W_4. The recording heads W_1 to W_4 and the reproducing heads R_1 to R_4 which form the pairs are alternately disposed in the direction Y.

When data is recorded or reproduced, the above-described combination head 13 is first moved to a position shown in Fig. 1. That is, it is moved to a position so as to make the center of the recording head W_1 and that of the reproducing head R_1 coincide with the center of the track T_1, the center of the recording head W_2 and that of the reproducing head R_2 coincide with the center of the track T_5, the center of the recording head W_3 and that of the reproducing head R_3 coincide with the center of the track T_9, and the center of the recording head W_4 and that of the reproducing head R_4 coincide with the center of the track T_{13}. Then, while maintaining the established relative positions, the magnetic tape 11 is allowed to run in the direction X when data is recorded so that data is simultaneously recorded on the tracks T_1 and T_9 by using the recording heads W_1 and W_3. When the recording to the tape-end has been completed, the magnetic tape 11 is allowed to run in the - X direction so that data is simultaneously recorded on the tracks T_5 and T_{13} by using the recording heads W_2 and W_4. After the recording to the tape-end has been completed, the combination head 13 is moved in the - Y direction by a distance a so that the center of the recording head W_1 and that of the reproducing head R_1 coincide with the center of the track T_2. With the established relative positions maintained, the magnetic tape 11 is again allowed to run in the direction X so that data is recorded on the tracks T_2 and T_{10} by using the recording heads W_1 and W_3. After recording to the tape-end has been completed, the magnetic tape 11 is then allowed to run in the direction - X so that data is recorded on the tracks T_6 and T_{14} by using the recording heads W_2 and W_4. Similarly, data is recorded on all of the tracks T_1 to T_{16}. According to this embodiment, since the number of the reproducing heads and the number of the recording heads are respectively arranged to be four with respect to the 16 tracks, the relative positions between the magnetic tape 11 and the combination head 13 become four positions.

Now, a tracking control device of the magnetic recording/reproducing apparatus according to the present invention will be described with reference to Figs.

2 and 3.

As shown in Figs. 2, 3a and 3b, th magn tic recording/r producing apparatus includes th combination head 21 having a light-r c iving d vice holding member 22 formed integrally with the combination head 21.

A magnetic tape 23 has a track group 24 constituted by the 48 tracks T_1 to T_{48} formed in the direction Y at the same pitch as shown in Fig. 2. According to this embodiment, width C of the magnetic tape 23 is arranged to be 6,35 mm (1/4 inch) and the track pitch is arranged to be 120 μm.

The combination head 21 includes 8 recording heads W_1 to W_8 and reproducing heads R_1 to R_8 which are integrally formed with the combination head 21. The recording heads W_1 to W_8 are disposed in the direction Y at a pitch of 720 μm, while the reproducing heads R_1 to R_8 are disposed in the direction X or - X forming pairs with the corresponding recording heads W_1 to W_8. The recording heads W_1 to W_8 and the reproducing heads R_1 to R_8 which form pairs are alternately disposed in the direction Y. When the magnetic tape 23 is allowed to run in the direction X, the four recording heads W_1, W_3, W_5 and W_7 of the combination head 21 perform the recording When the magnetic tape 23 is allowed to run in the direction - X, the four recording heads W_2, W_4, W_6 and W_8 perform the recording. Furthermore, whenever the magnetic tape 23 reciprocates once, the combination head 21 is moved in the direction - Y so that the combination head 21 is positioned at 6 relative positions with respect to the magnetic tape 23. As a result, all of the 48 tracks T_1 to T_{48} are subjected to the data recording/reproducing.

Furthermore, the light-receiving device holding member 22 has a reference outputting light receiving device 25a serving as a first light receiving device and a light receiving device 25b for detecting the relative position and serving as a second light receiving device, which are formed at positions adjacent to the - Y directional edge of the magnetic tape 23. The light receiving devices 25a and 25b can be moved in accordance with the movement of the combination head 21 in the ± Y directions since the light-receiving device holding member 22 is integrally formed with the combination head 21. The light receiving surface of the light receiving device 25a is arranged such that its Y directional width el is 120 μm which is the same width as that of the tracks T_1 to T_{48} while its X directional width is f with which a sufficient output level can be obtained. The light receiving device 25b is formed near the light receiving device 25a and the light receiving device 25b has a light receiving surface whose X directional width is arranged to b f and whos Y directi nal width e_2 is arrang d be a proper valu h lding the r lati nship $e_2 \geqq 720$ μm. Th utput l v l f r a unit area f the two light receiving devices 25a and 25b are arranged t be th sam . The reference-outputting light r ceiving d vice 25a is positi n d such that it is not conceal d by the magn tic tap 23. The light receiving d vic 25b for det cting th r lative positions is provided such that its - Y directional end is not covered by the -Y directional edge of the magnetic tape 23 when the recording head W_1 and the reproducing head R_1 are at the track position T_1. Furthermore, it is structured such that its light receiving area exposed from under the magnetic tape 23 becomes enlarged in accordance with the movement of the combination head 21 in the direction - Y. When the combination head 21 moved to each of the relative positions with respect to the magnetic tape 23, output Ea_1 from the light receiving device 25a and output Eb_1 from the light receiving device 25b hold the following relationship:

$$Eb_1 = m \times Ea_1$$

($1 \leqq m$, where m represents a positive integer)

The above-described numeral m represents each of the relative positions between the reproducing head R_1 of the combination head 21 and the plurality of tracks T_1 to T_6 positioned in a range in which the reproducing head R_1 can move, the numeral m can be a different value in accordance with each of the relative positions. That is, according to this embodiment, for example, when the recording head W_1 moved to the positions of the tracks T_1, T_2, T_3, T_4, T_5 and T_6, the each of the following relationships is established: $Eb_1 = Ea_1$, $Eb_1 = 2Ea_1$, $Eb_1 = 3Ea_1$, $Eb_1 = 4Ea_1$, $Eb_1 = 5Ea_1$ and $Eb_1 = 6Ea_1$.

The light receiving devices 25a and 25b are connected to a head operating unit (omitted from illustration). The head operating unit feedback-controls the combination head 21 in the ± Y directions so as to make outputs Ea1 and Eb1 from the light receiving devices 25a and 25b to hold the relationship Eb1 = m × Ea1. As a result, the relative positions between the magnetic tape 23 and the combination head 21 are held at predetermined positions as described above.

As shown in Figs. 3a, 3b, light emitting unit 26 capable of emitting light of a sufficient quantity to the light receiving devices 25a and 25b is disposed in a portion confronting the light receiving devices 25a and 25b with the - Y directional end of the magnetic tape 23 disposed therebetween.

When all of the tracks T_1 to T_{48} including the tracks T_1, T_{13}, T_{25}, and T_{37} are subjected to the data reproduction operation of the magnetic recording/reproducing apparatus structured as described above, the combination head 21 is operated by the head operating unit so that the reproducing head R_1 and the track T_1, the reproducing head R_3 and the track T_{13}, the reproducing head R_5 and the track T_{25} and the reproducing head R_7 and the track T_{37} are moved t th c rresponding relativ positions with respect to the magn tic tap 23. At this tim , the h ad perating unit m ves th combination head 21 so as t mak th output Ea_1 from the light receiving device 25a and th

output Eb_1 from th light receiving device 25b hold the following relationship:

$$Eb_1 = Ea_1$$

Furthermor , th head operating unit makes th combination head 21 follow the weaving of the magnetic tape 23 so that the relative positions between the magnetic tape 23 and the combination head 21 are maintained. Therefore, the relative position between the combination head 21 and the magnetic tape 23 can be held correctly. In this state,when the magnetic tape 23 is allowed to run in the X direction, the data on the tracks T_1, T_{13}, T_{25} and T_{37} are reproduced by the reproducing heads R_1, R_3, R_5 and R_7. When the reproduction to the end portion of the magnetic tape 23 has been completed, the magnetic tape 23 is allowed to run in the - X direction so that the each data on the tracks T_7, T_{19}, T_{31} and T_{43} is reproduced by the reproducing heads R_2, R_4, R_6 and R_8 respectively.

When data reproduction for one reciprocation has been completed, the combination head 21 is moved by the head operating unit to the relative position of the magnetic tape 23 at which the reproduction head R_1 corresponds to the track T_2, the reproduction head R_3 corresponds to the track T_{14}, the reproduction head R_5 corresponds to the track T_{26} and the reproduction head R_7 corresponds to the track T_{38}. At this time, the head operating unit moves the combination head 21 so as to make the output Ea1 from the light receiving device 25a and the output Eb_1 from the light receiving device 25b to hold the following relationship:

$$Eb_1 = 2Ea_1$$

When the magnetic tape 23 is allowed to run in the X direction, data on the tracks T_2, T_{14}, T_{26} and T_{38} is reproduced by the reproducing heads R_1, R_3, R_5 and R_7. Then, the magnetic tape 23 is allowed to run in the - X direction so that each data on the tracks T_8, T_{20}, T_{32} and T_{44} is reproduced respectively. Then, the similar operation is repeated until the magnetic tape 23 is reciprocated 6 times so that data on all of the tracks T_1 to T_{48} is reproduced. The above-described operation is similarly applied to the recording operation.

In general, the output from the light receiving device such as a photo-diode and that from the light emitting unit such as a light emitting diode can be easily changed due to the influence of the ambient temperature. However, the tracking control device according to this embodiment is structured such that the output Eb_1 from the light receiving device 25b for detecting the relative position is an integer multiple of the output Ea_1 from the reference-outputting light receiving device 25a at each of the relative positions between the magnetic tape 23 and the combination head 21. Therefore, the position c ntrol can be stably controll d without an influenc of temperature.

The positi ns of the light receiving d vices 25a and 25b are not limited to th ab ve-describ d description in which th y are disposed at the - Y directional edge of the magn tic tape 23. Another structur may b mploy d in which they ar disposed at the + Y dir ctional dg of th magnetic tape 23. In this case, th area of app aranc of the light r ceiving surface of the light receiving device 25b is decreased in accordance with the movement of the combination head 21 in the direction - Y. This structure may also be applied to the following embodiments.

A second embodiment of the present invention will be described with reference to Figs. 4 and 5. The elements having the same functions as those shown in the aforesaid embodiment are given the same reference numerals and their descriptions are omitted.

As shown in Figs. 4, 5a and 5b, the magnetic recording/reproducing apparatus according to this embodiment includes a combination head 21 for recording/reproducing data from the magnetic tape 23, the combination head 21 having a slit plate 27 integrally formed with the combination head 21. The structure of the magnetic tape 23 and that of the combination head 21 can be the same as those according to the first embodiment.

A light-receiving device holding member 22 is disposed to the side of the slit plate 27 opposite to the side confronting the magnetic tape 23, the light-receiving device holding member 22 being formed independently from the combination head 21 and the slit plate 27. The light-receiving device holding member 22 has a reference-outputting light receiving device 28a serving as the first light receiving device and a light receiving device 28b for detecting the relative position and serving as the second light receiving device at a position corresponding to the - Y directional end of the magnetic tape 23, the light receiving devices 28a and 28b being disposed in the direction X. The large portion of the light receiving surface of the light receiving device 28a and that of 28b are positioned in the direction - Y by larger degrees than the - Y directional edge of the magnetic tape 23. The light receiving surface of the light receiving device 28a and that of 28b are arranged such that the X directional width ℓ_H is larger than the X directional width f of a reference opening 27a and that of an opening 27b for detecting the relative position. On the other hand, the Y directional width ℓ_V, is larger than the Y directional width e_2 of an opening 27b for detecting the relative position. The output levels for a unit area of the two light receiving devices 28a and 28b are arranged to be the same. The above-described slit plate 27 has the reference opening 27a serving as the first opening and an opening 27b for detecting the relative position and serving as the second opening. The reference opening 27a is arranged such that its Y directional opening width e1 is 120 μm which is the sam width as that of the tracks T_1 to T_{48} whil its X directional opening width is f with which a sufficient output lev l can b btain d. Th pening 27b for detecting the relativ positi n is formed n ar th ref rence p ning 27a

and it has th X directional width of f and whose Y di-r ctional width e_2 has a prop r valu holding th re-lationship $_2 \geqq 720$ µm. The ref rence op ning 27a is positioned such that it is not obstructed by the magnetic tape 23. Furthermore, when the reference opening 27a is moved in the direction Y in accordance with the movement of the combination head 21 in the direction Y, it is arranged so as to allow a predetermined area of the light receiving surface of the light receiving device 28a to be illuminated for all of the movement range of the reference opening 27a. The opening 27b for detecting the relative positions . is provided such that its- Y directional end appears from the - Y directional edge of the magnetic tape 23 when the recording head W_1 and the reproducing head R_1 are at the track position T_1. Furthermore, the opening 27b is structured such that its opening area appearing from the magnetic tape 23 becomes enlarged and the illuminated area of the light receiving surface of the light receiving device 28b is increased in accordance with the movement of the combination head 21 in the direction - Y . When the combination head 21 moves to each of the relative positions with respect to the magnetic tape 23, output Ea_2 from the light receiving device 28a due to light which passed through the reference opening 27a and output Eb_2 from the light receiving device 28b due to light which passed through the opening 27b for detecting the relative position have the following relationship:

$$Eb_2 = m \times Ea_2$$

(1 $\leqq$ m, where m represents a positive integer)

The above-described numeral m represents the each of the relative positions between, for example, the reproducing head R_1 of the combination head 21 and the plurality of tracks T_1 to T_6 positioned in a range in which the reproducing head R_1 can move, the numeral m can be a different value in accordance with each of the relative positions. That is, according to this embodiment, when the recording head W_1 moved to, for example, the positions of the tracks T_1, T_2, T_3, T_4, T_5 and T_6, each of the following relationships is established: $Eb_2 = Ea_2$, $Eb_2 = 2Ea_2$, $Eb_2 = 3Ea_2$, $Eb_2 = 4Ea_2$, $Eb_2 = 5Ea_2$ and $Eb_2 = 6Ea_2$.

The light receiving devices 28a and 28b are connected to head operating unit (omitted from illustration). The head operating unit feedback-controls the combination head 21 in the ± Y directions so as to make the outputs Ea_2 and Eb_2 from the light receiving devices 28a and 28b to hold the relationship $Eb_2 = m \times Ea_2$. As a result, the relative positions between the magnetic tape 23 and the combination head 21 are held at a predetermined positions as described above.

As shown in Figs. 5a, 5b, the light emitting unit 26 is disposed in a p rtion confronting the ref rence pening 27a and th opening 27b for det cting the relativ p siti n in the slit plate 27 with the Y directi nal dge f th magn tic tap 23 disposed therebetween.

When all of the tracks T_1 to T_{48} including the tracks T_1, T_{13}, T_{25}, and T_{37} are subjected to th data reproduction operation of th magnetic r cording/reproducing apparatus structured as described above, the combination head 21 is operated by the head operating unit so that the reproducing head R_1 and the track T_1, the reproducing head R_3 and the track T_{13}, the reproducing head R_5 and the track T_{25} and the reproducing head R_7 and the track T_{37} are moved to the corresponding relative positions with respect to the magnetic tape 23. At this time, the head operating unit moves the combination head 21 so as to make the output Ea_2 from the light receiving device 28a and the output Eb_2 from the light receiving device 28b hold the following relationship:

$$Eb_2 = Ea_2$$

Furthermore, the head operating unit makes the combination head 21 follow the weaving of the magnetic tape 23 so that the relative positions between the magnetic tape 23 and the combination head 21 are maintained. In this case, when the magnetic tape 23 is allowed to run in the X direction, the data on the tracks T_1, T_{13}, T_{25} and T_{37} are reproduced. On the other hand, when the magnetic tape 23 is allowed to run in the - X direction, the data on the tracks T_7, T_{19}, T_{31} and T_{43} are reproduced.

When data reproduction for one reciprocation has been completed, the head operating unit feedback-controls to move the combination head 21 so as to make the output Ea_2 from the light receiving device 28a and the output Eb_2 from the light receiving device 28 establish the following relationship:

$$Eb_2 = 2\,Ea_2$$

When the magnetic tape 23 is allowed to run in the X direction, each data on the tracks T_2, T_{14}, T_{25} and T_{38} is reproduced respectively. Then, the magnetic tape 23 is allowed to run in the - X direction so that each data on the tracks T_8, T_{20}, T_{32} and T_{44} is reproduced respectively. Then, the similar operation is repeated so that data on all of the tracks T_1 to T_{48} is reproduced. The above-described operation is similarly applied to the recording operation.

According to this embodiment, the control is performed such that the quantity of light made incident upon the light receiving devices 28a and 28b after it passed through the - Y directional end of the magnetic tape 23, the reference opening 27a and the opening 27b for detecting the relative position is detected and the output Eb_2 from the light receiving device 28b becomes an integer multiple of the output Ea_2 from the light receiving device 28a. Therefore, the tracking control similar to the first embodiment can be performed. Acc rding t this embodiment, since th structure is arranged such that the slit plat 27 is moved together with th combinati n head 21, the weight of the m vabl portion can be reduced in comparison t the first mbodiment.

Similarly to th first mbodiment, th position control can be stably controll d without an influence of temp ratur .

Then, a third mbodim nt of the tracking control device of a magnetic recording/reproducing apparatus according to the present invention will be described with reference to Figs. 6 and 7.

As shown in Figs. 6, 7a and 7b, the magnetic recording/reproducing apparatus includes a combination head 21 for recording/reproducing data from a magnetic tape 23, the combination head 21 having a light-receiving device holding member 29 formed integrally with the combination head 21.

The above-described magnetic tape 23 has the track group 24 constituted by the 48 tracks T_1 to T_{48} formed in the Y direction at the same pitch as shown in Fig. 6. According to this embodiment, width C of the magnetic tape 23 is arranged to be 1/4 inch and the track pitch is arranged to be 120 μm.

The combination head 21 includes 8 recording heads W_1 to W_8 and reproducing heads R_1 to R_8 which are integrally formed with the combination head 21. The recording heads W_1 to W_8 are disposed in the Y direction at a pitch of 720 μm, while the reproducing heads R_1 to R_8 are disposed in the X or - X direction forming pairs with the corresponding recording heads W_1 to W_8. The recording heads W_1 to W_8 and the reproducing heads R_1 to R_8 which form pairs are alternately disposed in the Y direction. When the magnetic tape 23 is allowed to run in the X direction, the four recording heads W_1, W_3, W_5 and W_7 of the combination head 21 perform the recording, while the magnetic tape 23 is allowed to run in the - X direction, the four recording heads W_2, W_4, W_6 and W_8 perform the recording. Furthermore, whenever the magnetic tape 23 reciprocates once, the combination head 21 is moved in the - Y direction so that the combination head 21 is positioned at 6 relative positions with respect to the magnetic tape 23. As a result, all of the 48 tracks T_1 to T_{48} are subjected to the data recording/reproducing. Furthermore, the light-receiving device holding member 29 has light receiving device group 30 consisting of five light receiving devices Da_1 to Da_5 at positions corresponding to the - Y directional end portion of the magnetic tape 23. The light receiving devices Da1 to Da5 are arranged to have the same output level per unit area and to be moved in accordance with the movement of the combination head 21 in the ± Y directions since the light-receiving device holding member 29 is integrally formed with the combination head 21. The light receiving surface of each of the light receiving devices Da1 to Da5 is arranged such that its X directional width is f with which a sufficient output level can be obtained. The light rec iving device Da_1 is positioned at th largest degre in the - Y direction. The light receiving devices Da2 to Da4 ar resp ctively positioned such that their - Y directional nds ar successively shifted by 120 μm in th + Y direction which corresponds to the width of the ach of th tracks T_1 to T_{48}. Th light receiving d vice Da_5 is positioned from the - Y directional nd by 240 μm in th + Y dir ction. That is, pitch d_1 b tw en the light receiving devices Da_1 and Da_2, pitch d_2 between the light receiving devices Da_2 and Da_3 and pitch d_3 between the light receiving devices Da_3 and Da_4 are respectively arranged to be 120 μm. On the other hand, pitch d_4 between the light receiving devices Da_4 and Da_5 is arranged to be 240 μm. The relationship among the light receiving devices Da_1 to Da_5 and the pitches d_1 to d_5 are arranged as follows assuming that the i-th pitch in the + Y direction is d_i and the pitch of each of the tracks T_1 to T_{48} is d:

$$d_i = d \text{ when } i \leqq 2$$

$$d_i = (i - 2) \times d \text{ when } 3 \leqq i \leqq n - 1$$

(where i and n respectively represent positive integers)

According to this embodiment, the structure is arranged such that when, for example, the recording head W_1 and the reproducing head R_1 of the combination head 21 are at the track position T_1, the light receiving device Da_1 is positioned at a pitch 3d from the - Y directional edge of the magnetic tape 23. According to this embodiment, when the recording head W_1 moved to, for example, the positions of the tracks T_1, T_2, T_3, T_4, T_5 and T_6, the following relationships among the outputs Ea_1 to Ea_5 from the light receiving devices Da_1 to Da_5 are established: $Ea_3 = Ea_1 - Ea_2$; $Ea_4 = Ea_1 - Ea_2$; $Ea_4 = Ea_1 - Ea_3$; $Ea_5 = Ea_1 - Ea_2$; $Ea_5 = Ea_1 - Ea_3$; $Ea_5 = Ea_1 - Ea_4$.

The light receiving devices Da_1 to Da_5 are connected to head operating unit (omitted from illustration). The head operating unit feedback-controls the combination head 21 in the ± Y directions so as to make the outputs Ea_1 and Ea_5 from the light receiving devices Da_1 to Da_5 to hold the above-described relationship when the combination head 21 moved to the relative positions among the recording heads W_1 to W_8, the reproducing heads R_1 to R_8 and the tracks T_1 to T_{48}. As a result, the relative positions between the magnetic tape 23 and the combination head 21 are held at a predetermined positions as described above.

As shown in Figs. 7a, 7b, light emitting unit 26 capable of emitting light of a sufficient quantity to the light receiving devices Da_1 to Da_5 is disposed in a portion confronting the light receiving devices Da_1 to Da_5 with the - Y directional end of the magnetic tape 23 disposed therebetween.

When all of the tracks T_1 to T_{48} including the tracks T_1, T_{13}, T_{25}, and T_{37} are subjected to the data reproduction operation of the magnetic recording/reproducing apparatus structured as d scrib d abov , th combination head 21 is operated by the head op rating unit s that th r producing head R_1 and th track T_1, th reproducing h ad R_3 and the track T_{13}, the r producing head R_5 and th track T_{25} and the re-

producing head R_7 and the track T_{37} ar moved to the corresponding relative positions with r spect to th magnetic tap 23. At this time, th h ad op rating unit moves the combination head 21 so as t mak th output Ea_1 from the light receiving device Da_1 and the output Ea_2 from the light receiving device Da_2 hold the following relationship by the feedback control:

$$Ea_3 = Ea_1 - Ea_2$$

Furthermore, the head operating unit makes the combination head 21 follow the weaving of the magnetic tape 23 so that the relative positions between the magnetic tape 23 and the combination head 21 are maintained. Therefore, the relative position between the combination head 21 and the magnetic tape 23 can be held correctly. In this case, when the magnetic tape 23 is allowed to run in the direction X, the data on the tracks T_1, T_{13}, T_{25} and T_{37} are reproduced by the reproducing heads R_1, R_3, R_5 and R_7. When the reproduction to the end portion of the magnetic tape 23 has been completed, the magnetic tape 23 is allowed to run in the direction - X so that the data on the tracks T_7, T_{19}, T_{31} and T_{43} is reproduced by the reproducing heads R_2, R_4, R_6 and R_8.

When data reproduction for one reciprocation has been completed, the combination head 21 is moved by the head operating unit to the relative position of the magnetic tape 23 at which the reproduction head R_1 corresponds to the track T_2, the reproduction head R_3 corresponds to the track T_{14}, the reproduction head R_5 corresponds to the track T_{26} and the reproduction head R_7 corresponds to the track T_{38}. At this time, the head operating unit moves the combination head 21 so as to make the output Ea_1 from the light receiving device Da_1 and the output Ea_2 from the light receiving device Da_2 and the output Ea_4 from the light receiving device Da_4 establish the following relationship by the feedback control:

$$Ea_4 = Ea_1 - Ea_2$$

When the magnetic tape 23 is allowed to run in the direction X in this state, data on the tracks T_2, T_{14}, T_{26} and T_{38} is reproduced by the reproducing heads R1, R3, R5 and R7. Then, the magnetic tape 23 is allowed to run in the direction - X so that data on the tracks T_8, T_{20}, T_{32} and T_{44} is reproduced.

Similarly, the combination head 21 is moved after the one reciprocation at each of the track positions so as to hold the following relationships:

when data on tracks T_3, T_{15}, T_{27}, T_{39} and tracks T_9, T_{21}, T_{33}, T_{45} are reproduced,

$$Ea_4 = Ea_1 - Ea_3$$

when data on tracks T_4, T_{16}, T_{28}, T_{40} and the tracks T_{10}, T_{22}, T_{34}, T_{46} are reproduced ,

$$Ea_5 = Ea_1 - Ea_2$$

when data on tracks T_5, T_{17}, T_{29}, T_{41} and tracks T_{11}, T_{23}, T_{35}, T_{47} are reproduced ,

$$Ea_5 = Ea_1 - Ea_3$$

wh n data on tracks T_6, T_{18}, T_{30}, T_{42} and tracks T_{12}, T_{24}, T_{36}, T_{48} are reproduced,

$$Ea_5 = Ea_1 - Ea_4$$

As a r sult, th track switching operation and the track followup op ration are executed so that the data on all of th tracks T_1 to T_{48} are reproduc d. Th above-described operation is applied to the data recording operation.

According to this embodiment, since the structure is arranged such that the difference in output between two predetermined light receiving devices becomes the same as the output from a predetermined light receiving device, the position control can be stably obtained without an influence of temperatue.

According to this embodiment, the numbers of the relative positions between the magnetic tape 23 and the combination head 21 are arranged to be six. The number of the light receiving devices for detecting a plurality of relative positions can be reduced by increasing the number of the relative positions.

The positions of the light receiving devices Da_1 to Da_5 are not limited to the above-described structure in which they are positioned at the - Y directional end of the magnetic tape 23. A structure may be employed in which they are positioned at the + Y directional end of the magnetic tape 23 and the appearance area of the light receiving surface of each of the light receiving devices Da_1 to Da_5 decreases in accordance with the movement of the combination head 21 in the - Y direction. The above-described structure may be applied to the following embodiments.

Then, a fourth embodiment of the present invention will be described with reference to Figs. 8 and 9. In order to make the description easier, the elements having the same function as those in the above-described embodiments are given the same reference numerals and their descriptions are omitted.

As shown in Figs. 8, 9a and 9b, the magnetic recording/reproducing apparatus according to this embodiment includes a combination head 21 for recording/reproducing data from the magnetic tape 23, the combination head 21 having a slit plate 31 integrally formed with the combination head 21. The structure of the magnetic tape 23 and that of the combination head 21 are arranged to be the same as those according to the third embodiment.

A light-receiving device holding member 32 is disposed to the side of the slit plate 31 opposite to the side confronting the magnetic tape 23, the light receiving device holding member 32 being formed independently from the combination head 21 and the slit plate 31. The light-receiving device holding member 32 has five light receiving devices Db_1 to Db_5 at positions corresponding to the - Y directional end of the magnetic tape 23, the light receiving devices Db_1 to Db_5 being disposed in the X direction. The light r ceiving d vices Db_1 t Db_5 are arrang d to ind p ndently r ceive light which passes th - Y directional edg of the magnetic tape 23 and p nings A_1 to A_5 t be described lat r, The light receiving surface of each of th

light receiving devices Db_1 to Db_5 is arranged to b elongated in the Y direction, and th larg portion of th light rec iving surface of them ar positioned in th - Y direction by larger degr s than the - Y directional edge of the magnetic tape 23. The light receiving surface of each of light receiving devices Db_1 to Db_5 are arranged such that the X directional width ℓ_H is larger than the X directional width f of each of openings A_1 to A_5. Furthermore, the Y-directional width ℓ_V is arranged to be a value which corresponds to the Y-directional movement of the openings A_1 to A_5. The output levels for a unit area of the light receiving devices Db_1 to Db_5 are arranged to be the same.

The above-described slit plate 31 has the openings A_1 to A_5. The openings A_1 to A_5 are arranged such that its directional opening width is f with which a sufficient output level can be obtained from the light receiving devices Db_1 to Db_5. The opening A_1 is positioned at the largest degree in the - Y direction. The openings A_2 to A_4 are respectively positioned such that their - Y directional ends are successively shifted by 120 µm in the + Y direction which corresponds to the width of the each of the tracks T_1 to T_{48} from the - Y directional end of the opening A_1. The opening A_5 is positioned from the - Y directional end by 240 µm in the + Y direction. That is, pitch d_1 between the openings A_1 and A_2, pitch d_2 between the openings A_2 and A_3 and pitch d_3 between the openings A_3 and A_4 are respectively arranged to be 120 µm. On the other hand, pitch d_4 between the openings A_4 and A_5 is arranged to be 240 µm. The relationship among the openings A_1 to A_5 and the pitches d_1 to d_5 are arranged as follows assuming that the i-th pitch in the + Y direction is d_i and the width of each of the tracks T_1 to T_{48} is d:

$$d_i = d \text{ when } i \leqq 2$$

$$d_i = (i - 2) \times d \text{ when } 3 \leqq i \leqq n - 1$$

(where i and n respectively represent positive integers)

According to this embodiment, the structure is arranged such that when, for example, the recording head W_1 and the reproducing head R_1 of the combination head 21 are at the track position T_1, the opening A_1 is positioned at which it appears by 3d from the - Y directional edge the magnetic tape 23. According to this embodiment, when the recording head W_1 moved to, for example, the positions of the tracks T_1, T_2, T_3, T_4, T_5 and T_6, the following relationships among the outputs Eb_1 to Eb_5 from the light receiving devices Db_1 to Db_5 due to light which passed through the openings A_1 to A_5 and the - Y directional edge of the magnetic tape 23 are established: $Eb_3 = Eb_1 - Eb_2$; $E_{b4} = Eb_1 - Eb_2$; $Eb_4 = Eb_1 - Eb_3$; $Eb_5 = Eb_1 - Eb_2$; $Eb_5 = Eb_1 - Eb_3$; $Eb_5 = Eb_1 - Eb_4$.

The light receiving devices Db_1 to Db_5 are connected to an perating unit (omitted from illustration). The head perating unit fe dback-controls th combinati n h ad 21 in the ± Y directions so as to mak th outputs Eb_1 and Eb_5 from the light rec iving d - vices Db_1 t Db_5 hold the above-described relationships when th combination head 12 is moved to th relativ positions among the r cording h ads W_1 to W_8 and the reproducing heads R_1 to R_8 and the tracks T_1 to T_{48}. As a result, the relative positions between the magnetic tape 23 and the combination head 21 are held at a predetermined positions as described above.

As shown in Figs. 9a, 9b, light emitting unit 26 capable of emitting light of a sufficient quantity to the light receiving devices Db_1 to Db_5 is disposed in a portion confronting the light receiving devices Db_1 to Db_5 with the - Y directional end of the magnetic tape 23 and the openings A_1 to A_5 formed in the slit plate 31 disposed therebetween.

When all of the tracks T_1 to T_{48} including the tracks T_1, T_{13}, T_{25}, and T_{37} are subjected to the data reproduction operation of the magnetic recording/reproducing apparatus structured as described above, the combination head 21 is operated by the head operating unit so that the reproducing head R_1 and the track T_1, the reproducing head R_3 and the track T_{13}, the reproducing head R_5 and the track T_{25} and the reproducing head R_7 and the track T_{37} are moved to the corresponding relative positions with respect to the magnetic tape 23. At this time, the head operating unit moves the combination head 21 so as to make the output Eb_1 from the light receiving device Db_1, the output Eb_2 from the light receiving device Db_2 and the output Eb_3 from the light receiving device Db_3 hold the following relationship by the feedback control:

$$Eb_3 = Eb_1 - Eb_2$$

Therefore, the head operating unit makes the combination head 21 follow the weaving of the magnetic tape 23 so that the relative positions between the magnetic tape 23 and the combination head 21 are maintained. In this case, when the magnetic tape 23 is allowed to run in the X direction, the data on the tracks T_1, T_{13}, T_{25} and T_{37} are reproduced by the reproducing heads R_1, R_3, R_5 and R_7. When the magnetic tape 23 is allowed to run in the X direction, the data on the tracks T_7, T_{19}, T_{31} and T_{43} are reproduced by the reproducing heads R_2, R_4, R_6 and R_8.

Similarly, the combination head 21 is moved after the one reciprocation at each of the track positions so as to hold the following relationships:

When data on the tracks T_2, T_{14}, T_{26}, T_{38} and the tracks T_8, T_{20}, T_{32}, T_{44} are reproduced,

$$Eb_4 = Eb_1 - Eb_2$$

When data on tracks T_3, T_{15}, T_{27}, T_{39} and tracks T_9, T_{21}, T_{33}, T_{45} are reproduced,

$$Eb_4 = Eb_1 - Eb_3$$

When data n tracks T_4, T_{16}, T_{28}, T_{40} and the tracks T_{10}, T_{22}, T_{34}, T_{46} are reproduced

$$Eb_5 = Eb_1 - Eb_2$$

When data on tracks T_5, T_{17}, T_{29}, T_{41} and tracks T_{11}, T_{23}, T_{35}, T_{47} is reproduced

$$Eb_5 = Eb_1 - Eb_3$$

Wh n data on tracks T_6, T_{18}, T_{30}, T_{42} and tracks T_{12}, T_{24}, T_{36}, T_{48} is reproduced

$$Eb_5 = Eb_1 - Eb_4$$

As a result, the track switching operation and the track followup operation are executed so that the data on all of the tracks T_1 to T_{48} is reproduced. The above-described operation is applied to the data recording operation. As described above, since the structure according to this embodiment is arranged such that the slit plate 31 is moved together with the combination head 21, the weight of the movable portion can be reduced in comparison to the structure according to the third embodiment.

Similarly to the first embodiment, a stable position control can be obtained without an influence of temperature.

Then a fifth embodiment of the tracking control device of a magnetic recording/reproducing apparatus will be described with reference to Figs. 10 and 11.

As shown in Figs. 10, 11a and 11b, the magnetic recording/reproducing apparatus includes the combination head 21 for recording and reproducing data from the magnetic tape 23 and having a light-receiving device holding member 34 formed integrally with the combination head 21.

The above-described magnetic tape 23 has a track group 24 constituted by the 48 tracks T_1 to T_{48} formed in the direction Y at the same pitch as shown in Fig. 10. According to this embodiment, width C of the magnetic tape 23 is arranged to be 6,35 mm (1/4 inch) and the track pitch is arranged to be 120 µm. The weaving taken place in the magnetic tape 23 is restricted to smaller than ± 50 µm by flanges or the like (omitted from illustration) for ± Y directional edge of the magnetic tape 23.

The combination head 21 includes 8 recording heads W_1 to W_8 and reproducing heads R_1 to R_8 which are integrally formed with the combination head 21. The recording heads W_1 to W_8 are disposed in the Y direction at a pitch of 720 µm, while the reproducing heads R_1 to R_8 are disposed in the X or - X direction forming pairs with the corresponding recording heads W_1 to W_8. The recording heads W_1 to W_8 and the reproducing heads R_1 to R_8 which form pairs are alternately disposed in the Y direction. When the magnetic tape 23 is allowed to run in the X direction, the four recording heads W_1, W_3, W_5 and W_7 of the combination head 21 perform the recording, while the magnetic tape 23 is allowed to run in the direction - X, the four recording heads W_2, W_4, W_6 and W_8 perform the recording. Furthermore, whenever the magnetic tape 23 reciprocates once, the combination head 21 is moved in th - Y dir ction so that the combination head 21 is positioned at 6 relativ positions with respect to th magnetic tap 23. As a result, all of the 48 tracks T_1 to T_{48} are subject d to th data recording/reproducing. Furthermore, light receiving device group 34 serving as a light receiving devic group on on nd and consisting of six light r ceiving devices Da_1 to Da_6 is provid d in a portion corresponding to th portion in th vicinity f the + Y dir ctional nd of the magnetic tape 23. Similarly, light receiving device group 35 serving as a light receiving device group on another end and consisting of six light receiving devices Db_1 to Db_6 is provided in a portion corresponding to the portion in the vicinity of the - Y directional end of the magnetic tape 23. The number of the light receiving devices of the light receiving device groups 34 and 35 is arranged to be six which is the same as the number of the tracks T_1 to T_6 in a range in which, for example, the recording head W_1 and the reproducing head R_1 of the combination head 21 can be moved. The light receiving devices Da_1 to Da_6 and Db_1 to Db_6 are arranged to have the same output level. Furthermore, the light-receiving device holding member 33 is integrally formed with the combination head 21. As a result, the light receiving devices Da_1 to Da_6 and Db_1 to Db_6 can be moved in accordance with the movement of the combination head 21 in the ± Y directions. The light receiving surface of each of the light receiving devices Da_1 to Da_6 and Db_1 to Db_6 is arranged to have the Y-directional width e which can correspond to the weaving of the magnetic tape 23. The X-directional width is arranged to be f with which a sufficient output can be obtained. According to this embodiment, the above-described width e is 100 µm. The light receiving devices Da_1 to Da_6 and Db_1 to Db_6 are arranged such that the light receiving devices Da_1 and Db_1 are disposed at the - Y directional end and the light receiving devices Da_2 to Da_6 and Db_2 to Db_6 are formed in the + Y direction to form a line at the same pitch d (d = 120 µm) as the track pitch of the magnetic tape 23. The light receiving devices Da_1 and Db_1 are shifted by 6,35 mm (1/4 inch) in the direction Y of the magnetic tape 23. Furthermore, when, for example, the recording head W_1 and the reproducing head R_1 of the combination head 21 is at the track position T_1, the center of the light receiving devices Da_1 and that of Db_1 coincide with the ± Y directional edge of the magnetic tape 23.

The above-described light receiving devices Da_1 to Da_6 and Db_1 to Db_6 are connected to the head operating unit (omitted from illustration). The head operating unit feedback controls the combination head 21 so as to move it to each of the relative positions between the recording heads W_1 to W_8, the reproducing heads R_1 to R_8 and the tracks T_1 to T_{48} such that the difference in the output from the corresponding light receiving devices becomes zero, the combination head 21 being moved in the ± Y direction. As a result, th relativ position between the magnetic tap 23 and the combination head 21 can be held at a predet rmined position.

As shown in Figs. 11a, 11b, light emitting unit 36 capable of mitting a sufficient quantity of light to th

light receiving d vic s 34 and 35 are disposed at positions corr sponding to the light r c iving devic groups 34 and 35 with th ± Y directional dge of the magnetic tape 23 dispos d th reb tween.

At this time, the head operating unit feedback controls the combination head 21 so as to move it such that the difference in the output between the light receiving device Da_1 and the light receiving device Db_1 becomes zero. Furthermore, the head operating unit make the combination head 21 follow the weaving of the magnetic tape 23 so as to maintain the relative position between the magnetic tape 23 and the combination head 21.

When the reproduction of data for one reciprocation has been completed, the combination head 21 is moved to the relative position with the magnetic tape 23 at which the reproducing head R_1 and the track T_2 correspond to each other, the reproducing head R_3 and the track T_{14} correspond to each other, the reproducing head R_5 and the track T_{26} correspond. to each other and the reproducing head R_7 and the track T_{38} correspond to each other. At this time, the head operating unit feedback-controls the combination head 21 so as to move it such that the difference in the output between the light receiving device Da_2 and that of the light receiving device Db_2 becomes zero. When the magnetic tape 23 is allowed to run in the X direction, data on the tracks T_2, T_{14}, T_{26} and T_{38} is reproduced by the reproducing heads R_1, R_3, R_5 and R_7. Then, when the magnetic tape 23 is allowed to run in the direction - X so that the tracks T_8, T_{20}, T_{32} and T_{44} are subjected to the reproduction.

Similarly, when data on the tracks T_3, T_{15}, T_{27} and T_{39} and data on the tracks T_9, T_{21}, T_{33} and T_{45} is reproduced, the combination head 21 is moved so as to make the difference in the output between the light receiving devices Da3 and Db3 become zero. When data on the tracks T_4, T_{16}, T_{28} and T_{40} and data on the tracks T_{10}, T_{22}, T_{34} and T_{46} is reproduced, the difference in the output between the light receiving devices Da_4 and Db4 is made zero. When data on the tracks T_5, T_{17}, T_{29} and T_{41} and data on the tracks T_{11}, T_{23}, T_{35} and T_{47} is reproduced, the difference in the output between the light receiving devices Da_5 and Db_5 is made zero. When data on the tracks T_6, T_{18}, T_{30} and T_{42} and data on the tracks T_{12}, T_{24}, T_{36} and T_{48} is reproduced, the difference in the output between the light receiving devices Da_6 and Db_6 is made zero. The combination head 21 is moved after one reciprocation at each track position has been completed. Thus, the track switching operation and the track following-up operation are executed until data on all of the tracks T_1 to T_{48} is reproduced. The above-described operation is appli d t th recording operation.

Then, a sixth embodim nt f th present invention will b d scrib d with ref renc t Figs. 12 and 13. In rder t make the description easy, the elements having the sam functi ns as th se according to th afor said embodiments are giv n the same reference numerals and th ir descriptions ar omitted.

As shown in Figs. 12, 13a and 13b, th magn tic recording/r producing apparatus includ s th combination head for recording and reproducing data from the magnetic tape 23, the combination head 21 having a slit plate 37 integrally formed with the combination head 21. The structures of the magnetic tape 23 and the combination head 21 are the same as those according to the fifth embodiment. The weaving of the magnetic tape 21 is restricted to ± 50 μm or less by flanges or the like (omitted from illustration) for restricting the ± Y directional end of the magnetic tape 21.

The light-receiving device holding member 38 is disposed to the side of the slit plate 37 opposite to the side which confronts the magnetic tape 23, the light-receiving device holding member 38 being independently formed from the combination head 21 and the slit plate 37.

The light-receiving device holding member 38 has light receiving device groups 39 and 40 which respectively consist of six light receiving devices Di_1 to Di_6 and Dj_1 to Dj_6 at the positions corresponding to the ± Y directional ends of the magnetic tape 23. The light receiving devices Di1 to Di_6 and Dj_1 to Dj_6 are arranged such that the light receiving devices Di_1 and Dj_1 are disposed at the + X directional end and the other light receiving devices are successively disposed in the - X direction to form a line at a pitch g. Furthermore, their Y-directional centers coincide with the ± Y- directional end of the magnetic tape 23. The above-described light receiving devices Di_1 to Di_6 and Dj_1 to Dj_6 are respectively arranged to independently receive light which passed through the ± Y-directional end of the magnetic tape 23 and openings Si_1 to Si_6 and Sj_1 to Sj_6 to be described later. The light receiving surfaces of the light receiving devices Di_1 to Di_6 and those Dj_1 to Dj_6 are arranged such that the Y directional width ℓ_v is larger than the Y directional width e of openings Si_1 to Si_6 and Sj_1 to Sj_6, and the X directional width ℓ_H is smaller than the above-described pitch g. The output levels for a unit area of the light receiving devices Di_1 to Di_6 and Dj_1 to Dj_6 are arranged to be the same.

The above-described slit plate 37 has an opening group 41 consisting of six openings Si_1 to Si_6 and serving as an opening group at an end portion at positions corresponding to the light receiving devices Di_1 to Di_6. On the other hand, opening group 42 consisting of six openings Sj_1 to Sj_6 and serving as an opening group at another end portion at positions corresponding to the light receiving devices Dj_1 to Dj_6. The openings ar provided by six so as to correspond to the number of the tracks T_1 to T_6 in a range in which, for xample, th r cording head W1 and th reproducing head R1 can mov which form pairs. Th penings Si_1 t Si_6 and Sj1 to Sj_6 mov . in accordance

with th ± Y dir ctional mov ment of the combination h ad 21 sinc the slit plate 37 is integrally formed with th combination head 21. Each of the op nings Si_1 to Si_6 is arrang d to hav a Y-dir ctional width (e = 100 μm) so as to correspond to the weaving of the magnetic tape 23. On the other hand, their X-directional width is arranged to be a width f with which a sufficient output can be obtained from the light receiving devices Di_1 to Di_6 and Dj_1 to Dj_6. The openings Si_1 to Si_6 and Sj_1 to Sj_6 are arranged such that the openings Si_1 and Sj_1 are disposed at the + X directional end and at the - Y directional end and the openings Si_2 to Si_6 and Sj_2 to Sj_6 are respectively and successively disposed in the + Y direction at the same pitch d (d = 120 μm) as the track pitch of the magnetic tape 23 and at a pitch g in the - X direction. Furthermore, the light receiving devices Di_1 to Di_6 and the light receiving devices Dj_1 to Dj_6 are shifted by 6,35 mm (1/4 inch) which corresponding to the width of the magnetic tape 23 in the direction Y. According to this embodiment, when for example, the recording head W_1 and the reproducing head R_1 of the combination head 21 are at the track position T1, the Y-directional centers of the openings Si_1 and Sj_1 coincide with the centers of the light receiving devices Di_1 and Dj_1, that is, the ± Y directional ends of the magnetic tape 23.

The above-described light receiving devices Di_1 to Di_6 and Dj_1 to Dj_6 are connected to the head operating unit (omitted from illustration). The head operating unit feedback-controls the combination head 21 to move it in the ± Y direction of the magnetic tape 23 such that the difference in the output between light receiving devices Di_1 to Di_6 and Dj_1 to Dj_6 which form pairs becomes zero when the combination head 21 has been shifted to each of the relative positions between the recording heads W_1 to W_8 and the reproducing heads R_1 to R_8 and the tracks T_1 to T_{48}. As a result, the relative position between the magnetic tape 23 and the combination head 21 is maintained at a predetermined position.

As shown in Figs. 13a, 13b, the light emitting unit 43 capable of emitting light to the light receiving devices 39 and 40 is provided at the positions confronting the above-described light receiving device groups 39 and 40 with the ± Y directional end of the magnetic tape 23 and the slit plate 37 disposed therebetween. At this time, the head operating unit feedback-controls to calculate the difference in the output between the light receiving device Di1 and the light receiving device Dj_1 due to incident light from the light emitting unit 43 via the openings Si_1 and Sj_1 formed in the slit plate 37 and the ± Y directional end of the magnetic tape 23. The combination head 21 is operated such that the diff renc in the output b com s zero. Therefore, th combination head 21 moves so as to foll w th weaving f the magn tic tap 23. As a result, th relativ positions b tw en the combinati n h ad 21 and the magnetic tape 23 can b maintained correctly. When th magn tic tape 23 is allowed to run in th direction X in this stat , data on the tracks T_1, T_{13}, T_{25} and T_{37} is r produc d by th reproducing heads R_1, R_3, R_5 and R_7. When the magnetic tape 23 is allow d to run in the - X direction, data on the tracks T_7, T_{19}, T_{31} and T_{43} is reproduced by the reproducing heads R_2, R_4, R_6 and R_8.

When the reproduction of data for one reciprocation has been completed, the combination head 21 is moved so as to make the following differences in the following outputs zero: when data on the tracks T_2, T_{14}, T_{26} and T_{38} and data on the tracks T_8, T_{20}, T_{32} and T_{44} is reproduced, the output difference between the light receiving devices Di_2 and Dj_2 due to incident light via the openings Si_2 and Sj_2 and the edges of the magnetic tape 23; when data on the tracks T_3, T_{15}, T_{27} and T_{39} and data on the tracks T_9, T_{21}, T_{33} and T_{45} is reproduced, the output difference between the light receiving devices Di_3 and Dj_3 due to incidental light via the openings Si_3 and Sj_3 and the edges of the magnetic tape 23; when data on the tracks T_4, T_{16}, T_{28} and T_{40} and data on the tracks T_{10}, T_{22}, T_{34} and T_{46} is reproduced, the output difference between the light receiving devices Di_4 and Dj_4 due to incident light via the openings Si_4 and Sj_4 and the edges of the magnetic tape 23; when data on the tracks T_5, T_{17}, T_{29} and T_{41} and data on the tracks T_{11}, T_{23}, T_{35} and T_{47} is reproduced, output difference between the light receiving devices Di_5 and Dj_5 due to incidental light via the openings Si_5 and Sj_5 and the edges of the magnetic tape 23; when data on the tracks T_6, T_{18}, T_{30} and T_{42} and data on the tracks T_{12}, T_{24}, T_{36} and T_{48} is reproduced, the output difference between the light receiving devices Di6 and Dj_6 due to incident light via the openings Si_6, Sj_6 and the edges of the magnetic tape 23. As a result, the track switching operation and the track following up operation can be performed and the data reproduction from all of the tracks T_1 to T_{48} is completed. The above-described operation is applied to the recording operation.

Then, a seventh embodiment of the present invention will be described. According to this embodiment, an example of a serpentine magnetic recording/reproducing apparatus is provided. The magnetic recording/reproducing apparatus according to this embodiment is structured such that a combination head having recording heads and the reproducing heads whose number is smaller than the number of the tracks of the magnetic tape is allowed to run once in the direction of the magnetic tape on which a plurality of tracks are formed in parallel in the direction in which the tape runs. As a result, a plurality of tracks are simultaneously subjected to the recording or the r producing. Furthermore, the combinati n head is moved by th head op rating means in the widthwise dir cti n of the magnetic tape by the track switching op rati n. As a result, data is rec rd d/reproduced from all of th tracks.

Th n, the magnetic recording/reproducing apparatus according to this mbodim nt will b d scribed with reference to Figs. 14, 15 and 16.

Fig. 14 is a p rspectiv vi w which illustrates the magnetic recording/reproducing apparatus to which no magnetic tape has been loaded. Fig. 15 illustrates a state in which the magnetic tape has been loaded.

A combination head 51 for recording or reproducing data from a magnetic tape 52 is fastened to a holder 53 serving as a member for holding the combination head 51. Light-receiving groups 54 and 55 for detecting the vertical two ends of the magnetic tape 52 are secured to a portion in the vicinity of the combination head 51.

That is, a movable portion 56 is constituted by combining the combination head 51, the light receiving device groups 54 and 55 and the holder 53. The holder 53 is fastened between the free ends of parallel leaf springs 57a and 57b whose one ends are secured to a fastening portion 58. The fastening portion 58 is fastened to a main frame (omitted from illustration) of the magnetic recording/reproducing apparatus. As head moving unit for moving the combination head 51 to the widthwise direction of the magnetic tape 52, a voice coil type linear motor 59 having no friction loss and dead zone is employed. The voice coil type linear motor 59 includes a square yoke type magnetic circuit 60 secured to the main frame and a coil 61 for generating moving force. The above-described movable portion 56 is connected to the coil 61 by the bobbin 62 which connects the movable portion 56 and the coil 61 such that it acts in synchronization with the movement of the coil 61 and the power generated by the coil 61 passes through a portion in the vicinity of the center of gravity of the movable portion 56. As a result of the above-described structure, precise servo control can be performed in the operation of the combination head 51.

Reference numerals 60a and 60b represent magnets of the voice coil type linear motor 59. Reference numeral 60C represents a central magnet into which the coil 61 is inserted from outside. Reference numeral 60d represents an outside magnetic pole,60e represents a common magnetic pole positioned in close contact with the terminals of each of outer magnetic poles confronting the central magnetic pole 60C and outer magnetic poles 60d.

Thus, a closed circuit of the magnetic circuit 60 is constituted so that the combination head 51 does not receive an influence of a leaked flux from the magnetic circuit 60. Therefore, the influence of the leaked flux from the voice coil type linear motor 59 upon the combination head 51 and the magnetic tape 52 can be reduced to ten and several Oes. Furthermore, the main frame is provided with a light emitting d vice 63 positi n in th pposit directi n t the light receiving devices 54 and 55 with the magnetic tape 52 is disposed thereb tw en and fix d guides 64a and 64b disposed on the both sides of the combination h ad 51 and guiding th magnetic tap 52.

Fig. 16 illustrat s th structur of th tracking control according to this mbodiment. As shown in Fig. 16, the magnetic tape 65 has a track group 66 consisting of 48 tracks T_1 to T_{48} at the same pitch in the direction Y. According to this embodiment, the width C of the magnetic tape 65 is arranged to be 6,35 mm (1/4 inch) and the track pitch is arranged to be 120 µm. The combination head 67 includes 16 recording heads W_1 to W_{16} and reproducing heads R_1 to R16 which are formed integrally. The recording heads W_1 to W_{16} are disposed in the direction Y at a pitch of 360 µm. The reproducing heads R_1 to R_{16} form a pair with the corresponding recording heads W_1 to W_{16} in the X or - X direction. The recording heads W_1 to W_{16} and the reproducing heads R_1 to R_{16} each forming a pair are alternately disposed in the direction Y.

In the combination head 67 thus structured, when the magnetic tape 65 is allowed to run in the direction X, 8 recording heads W_{2n-1} (n = 1 to 8) perform the recording operation, while when the magnetic tape 65 is allowed to run in the direction- X, 8 recording heads W_{2n} (n = 1 to 8) perform the recording. Furthermore, the combination head 67 is moved in the direction - Y whenever the magnetic tape reciprocates. Therefore, the relative position with respect to the magnetic tape 65 is changed three times. As a result, all of the 48 tracks T_1 to T_{48} are subjected to the data recording/reproducing. The holder 68 has, at its portion corresponding to the + Y directional end of the magnetic tape 65, a light-receiving device group 69 consisting of three light receiving devices Da_1 to Da_3 and disposed at an end. Furthermore, a light-receiving device group 70 consisting of three light receiving devices Db_1 to Db_3 and disposed at the other end is provided in a portion corresponding to the - Y directional end. The number of the provided light receiving devices 69 and 70 corresponds to the number of the tracks T_1 to T_3 in a range in which, for example, the pair of the recording head W_1 and the reproducing head R_1 of the combination head 67 operate. The light receiving devices Da_1 to Da_3 and Db_1 to Db_3 are arranged to have the same output level for a unit light receiving area. Furthermore, they are integrally formed with the combination head 67 by the holder 68. As a result, they can be moved in accordance with the movement of the combination head 67 in the ± Y direction. The light receiving devices Da_1 to Da_3 and Db_1 to Db_3 are disposed at the same pitch (120 µm) as the track pitch of the magnetic tape 65, and the light receiving devices Da_1 and Db1 are shifted from each other in the direction Y by the width 6,35 mm (1/4 inch) of th magnetic tape 65. Furthermore, when, for xample, th recording head W_1 and th reproducing head R_1 f th c mbination h ad 67 are at th track positi n T_1, the cent rs of the light receiving d vices Da_1 and Db_1 coincide with the ± Y directi nal nds of

th magn tic tape 65.

As a result of th above-d scribed structure, when data on all of th tracks T_1 to T48 is r produced, th h ad op rating unit is feedback-controlled so as to make the output difference between the light receiving devices Da_1 and Db_1 becomes zero when the magnetic tape 65 is allowed to run in the direction X. With the thus realized precise tracking control performed, data on 8 tracks T_{6n-5} (n = 1 to 8) is reproduced by 8 reproducing heads R_{2n-1} (n = 1 to 8). When the reproduction to the end portion of the magnetic tape 65 has been ended, the magnetic tape 65 is allowed to run in the direction - X. During this, the feedback control is maintained such that the output difference between the light receiving devices Da_1 and Db_1 is made zero is conducted so that the data on 8 tracks T_{6n-2} (n = 1 to 8) is reproduced by 8 reproducing heads R_{2n} (n = 1 to 8). Similarly, the track switching operation and the track follow-up operation are conducted. Thus, data on all of the tracks T_1 to T_{48} is ended. The above-described operation is also applied to the recording operation.

Although the combination head 67 is held by a parallel leaf spring according to this embodiment, the present invention is not limited to the description above. A structure may be employed in which it is held by a shaft and a bearing in a sliding method.

Fig. 17 illustrates the transfer function of the spring system of the parallel leaf spring supporting structure shown in Figs. 14 and 15. As shown in Fig. 17, the second resonance frequency becomes 1.2 kHz with respect to the first resonance frequency 30 Hz. With the characteristics described above, the closed loop servo with the cutoff frequency of about 500 Hz can be obtained by performing a servo control such as the phase compensation. Therefore, the tape weaving of, for example, 100 Hz can be followup controlled at a compression ratio of about -20 to -30 dB.

Fig. 18 illustrates the transfer function for a structure in which the combination head 51 and the holder 53 are not supported between the parallel leaf springs 57a and 57b Figs. 14 and 15. Since the second resonant frequency is about 450 Hz, the cutoff frequency becomes lowered excessively and the servo gain reduction becomes too lowered to conduct the closed loop servo. Therefore, a tracking control with a satisfactory followup characteristics cannot be conducted.

Since the voice coil type linear motor 59 is used to operate the combination head 51 and since the power generated by the linear motor 59 is arranged to pass through a portion in the vicinity of the center of gravity of the movable portion 56, the operation of the combination head 51 can be precisely servo-controlled.

It should b understood that the present inv ntion is n t limit d to the specific embodiments described in this specification, except as d fined in th app nd- d claims.

Claim

1. A magnetic recording/reproducing apparatus comprising a composit magnetic h ad (13; 21; 51; 67) having a number of recording/reproducing heads (W_{1-8}, R_{1-8}; W_{1-16}, R_{1-16}) less than the number of tracks (24; 66; T_{1-48}) which are provided on a magnetic tape (11; 23; 52; 65) in parallel with each other and with the direction (X) in which the tape runs, said composite head being movable relative to the magnetic tape in the widthwise direction (Y) of the tape to a number of operational positions at each of which said heads are aligned with a respective set of desired ones of said tracks, characterised by control means for setting and maintaining said composite head at a selected one of said positions, said control means including an optical system (26, 22; 26, 27, 22; 26, 29; 26, 31, 32; 36, 33; 43, 37, 38; 63, 68) having a light emitting means (26; 36; 43; 63) and a multi-element light receiving means (25a, 25b; 28a, 28b; 30; Db_{1-6}; 34, 35; 39, 40; 69, 70) disposed on opposite sides of the tape, and arranged to transmit light past at least one edge of the tape in such a way that the pattern of light transmitted to said multi-element light receiving means is dependent upon said operational position of the composite head relative to the tape.

2. An apparatus as claimed in claim 1, wherein the light receiving means comprises first (25a; 28a) and second (25b; 28b) light receiving elements, the arrangement being such that the output of the second light receiving element is a multiple of the output of the first light receiving element in dependence upon the operational position of the composite magnetic head.

3. An apparatus as claimed in claim 2, wherein in each operational position of the composite magnetic head a constant area of the first light receiving element is exposed to light from the light emitting means (26) whilst the area of the second light receiving element exposed to light from the light emitting means varies in dependence upon the operational position of the composite magnetic head.

4. An apparatus as claimed in claim 3, wherein the first light receiving element is positioned so that the tape does not obstruct light from the light emitting means, whereas the second element is positioned so that an edge of the tape obstructs light passing to th second lement in d pendence upon th operati nal position of the composite magnetic head.

5. An apparatus as claimed in claim 4, wherein th quantity of light received by th s cond light receiving l ment at ach operational position of the composite magnetic head is an integer multiple of the light received by the first element, wherein the integer multiple corresponds to the respective operational position.

6. An apparatus as claimed in any one of the preceding claims, wherein the light receiving means (25a, 25b) is mounted to and movable with the composite magnetic head.

7. An apparatus as claimed in any one of claims 1-5, wherein the optical system includes a slit plate (27) mounted to the composite magnetic head and movable therewith, the slit plate being movable between the light emitting means (26) and light receiving means (28a, 28b) and having aperture means (27a, 27b) therein which controls the pattern of light transmitted to the first and second light receiving elements in dependence upon the operational position of the composite magnetic head.

8. An apparatus as claimed in claim 7, wherein the aperture means comprises a first aperture (27a) allowing a constant area of said first light receiving element (28a) to be illuminated by said light emitting means (26) and a second aperture (27b) illuminating an area of the second element (28b) in dependence upon the operational position of the composite magnetic head.

9. An apparatus as claimed in claim 1, wherein three or more spaced apart light receiving elements (Da_1-Da_5, Db_1-Db_5) are provided adjacent an edge of the tape, the arrangement being such that outputs of selected ones of the light receiving elements have predetermined relationships in each of the operational positions.

10. An apparatus as claimed in claim 9, wherein for each operational position the output of a selected light receiving element (Da_1-Da_5, Db_1-Db_6) equals the sum of the outputs of two other selected light receiving elements (Da_1-Da_5, Db_1-Db_5).

11. An apparatus as claimed in claim 9 or claim 10, wherein the light receiving elements are mounted to and movable with the composite magnetic head.

12. An apparatus as claimed in claim 11, wherein the light receiving el ments are in perati n displaced by diff ring amounts from an edge f th tap .

13. An apparatus as claimed in claim 12, wher in the pitch d_i betw n th nds of adjacent light r ceiving elements Da_i and Da_{i+1} in th lateral (Y) direction of the tap is d termined according to:

$$d_i = d \text{ when } i \leqq 2$$

and

$$d_i = (i - 2)\, d \text{ when } 3 \leqq i \leqq n - 1$$

where d is the pitch of the tracks on the magnetic tape and n is the number of light receiving elements.

14. An apparatus as claimed in any one of claims 9 to 12, wherein the light receiving elements are of constant width in the longitudinal direction (X) of said tape.

15. An apparatus as claimed in claim 9 or claim 10 wherein the optical system includes a slit plate (31) mounted to the composite magnetic head and movable therewith, the slit plate (31) being movable between the light emitting means (26) and the light receiving elements (Db_1 - Db_5) and having aperture means (A_1 - A_5) which selectively allows light to pass from the light emitting means (26) to selected ones of the light receiving elements (Db_1 - Db_5, 32) in a pattern dependent upon the operational position of the composite magnetic head.

16. An apparatus as claimed in claim 15, wherein the aperture means (A_1-A_5) comprises a plurality of slits (A_1-A_5), each said slit being arranged to allow light to pass from the light emitting means (26) to a respective light receiving element (Db_1 - Db_5) in selected ones of the operational positions of the composite magnetic head.

17. An apparatus as claimed in claim 16, wherein the pitch d_i between the ends of the adjacent slits A_i and A_{i+1} of the slit plate (31) in the lateral direction (Y) of the magnetic tape is determined according to:

$$d_i = d \text{ when } i \leqq 2$$

$$d_i = (i - 2d) \text{ when } 3 \leqq i \leqq n - 1$$

where d is the pitch of the tracks on the magnetic tape and n is the number of slits in the slit plate.

18. Apparatus according to any one of claims 15 to 17, wherein the slits (A_1 - A_5) are all of constant width (f) in the longitudinal (X) direction of said tape.

19. An apparatus as claimed in claim 1, wherein a plurality of light receiving elements (Da_1 - Da_6, Db_1 - Db_6; Di_1 - Di_6, Dj_1 - Dj_6; Db_1 - Db_3, Da_1 - Da_3) are provided adjacent each edg f th magnetic tap .

20. An apparatus as claimed in claim 19, wherein the number of light receiving lements adjacent ach edge of the tap is equal to th number of operational positions.

21. An apparatus as claimed in claim 20 or claim 21, wherein pairs of light receiving elements (Da_1 - Da_8, Db_1 - Db_6; Di_1 - Di_8, Dj_1 -Dj_8; Db_1 - Db_3, Da_1 - Da_3) are arranged with one element of each pair adjacent each side of the magnetic tape, the arrangement being such that the outputs of each pair of light receiving elements satisfy a predetermined relationship when the composite magnetic head is in a respective one of the operational positions.

22. An apparatus as claimed in claim 21, wherein the predetermined relationship is that the outputs of the light receiving elements of a pair of light receiving elements are balanced.

23. An apparatus as claimed in claim 21 or 22, wherein the light receiving elements are mounted to said composite magnetic head and movable therewith, the light receiving elements being positioned so that light receiving elements of respective pairs of light receiving elements are substantially aligned with respective edges of the magnetic tape in each respective operational position.

24. An apparatus as claimed in claim 21 or claim 22, wherein the optical system includes a slit plate (37) mounted to the composite magnetic head and movable between the light emitting means (43) and the light receiving elements (Di_1 - Di_8, Dj_1 - Dj_8) having aperture means (Si_1 - Si_8, Sj_1 - Sj_8) therein which allows light to pass to respective pairs of the light emitting elements in each respective operational position.

25. An apparatus as claimed in claim 24, wherein the light receiving elements are arranged along the edges of said magnetic tape and the aperture means comprises a plurality of apertures (Si_1 - Si_8, Sj_1 - Sj_8) which permit light to pass to a respective pair of light receiving elements in each respective operational position.

26. An apparatus as claimed in any one of claims 1 and 23 to 25 wherein said light emitting means transmits light past both edges of the tape.

27. An apparatus as claim d in any one of th preceding claims wherein said light receiving means are s dispos d that outputs from said light receiving elements hav a pred termin d relation which governs said control means wh n said composite magn tic head is in each operational position.

28. An apparatus as claimed in any one of th preceding claims including head operating means capable of moving said combination head in the widthwise direction of said tape.

29. An apparatus according to any one of the preceding claims, wherein said composite magnetic head is supported between free ends of two parallel leaf springs (57a, 57b).

30. An apparatus as claimed in any one of the preceding claims, wherein the control means includes a voice coil type linear motor (59) for setting and maintaining the composite head at a selected one of said operational positions.

31. An apparatus as claimed in claim 30, wherein the voice coil type linear motor has a magnetic circuit which is closed in the direction of the composite magnetic head and in the direction of the magnetic tape.

32. An apparatus according to claim 30 or claim 31, when dependent on claim 29 further including a support means (53) disposed between the free ends of the parallel leaf springs (57a, 57b), the support means supporting the composite magnetic head and being responsive to movement of the coil of the voice coil type linear motor to set and maintain the operational position of the composite magnetic head.

33. An apparatus as claimed in claim 32, wherein the voice coil is connected to the support means in such a manner that force from the voice coil is applied in the vicinity of the centre of gravity of the support means.

34. A serpentine type magnetic recording/reproducing system incorporating the apparatus of any one of the preceding claims.

Patentansprüche

1. Magnetisches Aufzeichnungs-/Wiedergabegerät mit einem Verbundmagnetkopf (13; 21; 51; 67) mit einer Anzahl von Aufzeichnungs-/Abspielköpfen (W_{1-8}, R_{1-8}; W_{1-16}, R_{1-16}), deren Anzahl kleiner als die Anzahl von Spuren (24; 66; T_{1-48}) ist, die auf in m Magnetband (11; 23; 52; 65) parall l zueinand r in d r Richtung (X) v rhanden sind, in d r das Band läuft, wob i d r V rbundk pf relativ zum Magnetband in Breitenrichtung (Y) des

Bands in eine Anzahl von B triebspositionen verstellbar ist, in den n di Köpf jeweils mit einem ntsprechenden Satz g wünscht r Spuren ausgericht t sind, **gek nnz ichnet durch** ine Steuerungseinrichtung zum Einstellen und Festhalten des Verbundkopfs in einer ausgewählten unter den Positionen, wobei die Steuerungseinrichtung ein optisches System (26, 22; 26, 27, 22; 26, 29; 26, 31, 32; 36, 33; 43, 37, 38; 63, 68) mit einer Lichtemissionseinrichtung (26; 36; 43; 63) und einer Lichtempfangseinrichtung (25a, 25b; 28a, 28b; 30; Db_{1-6}; 34, 35; 39, 40; 69, 70) mit mehreren Elementen, die an entgegengesetzten Seiten des Bands angeordnet sind, aufweist, und die so ausgebildet ist, daß sie Licht an mindestens einer Kante des Bands vorbei auf solche Weise überträgt, daß das Muster des an die mehrelementige Lichtempfangseinrichtung übertragenen Lichts von der Betriebsposition des Verbundkopfs relativ zum Band abhängt.

2. Gerät nach Anspruch 1, bei dem die Lichtempfangseinrichtung ein erstes (25a; 28a) und ein zweites (25b; 28b) Lichtempfangselement aufweist, wobei die Anordnung dergestalt ist, daß das Ausgangssignal des zweiten Lichtempfangselements ein Mehrfaches des Ausgangssignals des ersten Lichtempfangselements abhängig von der Betriebsposition des Verbundmagnetkopfs ist.

3. Gerät nach Anspruch 2, bei dem in jeder Betriebsposition des Verbundmagnetkopfs eine konstante Fläche des ersten Lichtempfangselements Licht von der Lichtemissionseinrichtung (26) ausgesetzt ist, während sich die Fläche des zweiten Lichtempfangselements, das Licht von der Lichtemissionseinrichtung ausgesetzt ist, abhängig von der Betriebsposition des Verbundmagnetkopfs ändert.

4. Gerät nach Anspruch 3, bei dem das erste Lichtempfangselement so positioniert ist, daß das Band das Licht von der Lichtemissionseinrichtung nicht verdeckt, wohingegen das zweite Element so positioniert ist, daß eine Kante des Bands Lichts zum zweiten Element laufenden Lichts abhängig von der Betriebsposition des Verbundmagnetkopfs sperrt.

5. Gerät nach Anspruch 4, bei dem die Menge des vom zweiten Lichtempfangselement in jeder Betriebsposition des Verbundmagnetkopfs empfang n n Lichts in ganzzahliges Vielfaches d s vom erst n Element empfangenen Lichts ist, wob i das ganzzahlige Vielfach einer jeweiligen Betriebsposition ntspricht.

6. G rät nach einem der vorstehenden Ansprüche, bei d m di Lichtempfangs inrichtung (25a, 25b) am V rbundmagn tkopf angebracht und mit dies m verstellbar ist.

7. Gerät nach einem der Ansprüche 1 - 5, bei dem das optische System eine Schlitzplatte (27) aufweist, die am Verbundmagnetkopf angebracht ist und mit diesem verstellbar ist und zwischen der Lichtemissionseinrichtung (26) und der Lichtempfangseinrichtung (28a, 28b) verstellbar ist und eine Öffnungseinrichtung (27a, 27b) beinhaltet, die das Muster des zum ersten und zweiten Lichtempfangselement übertragenen Lichts abhängig von der Betriebsposition des Verbundmagnetkopfs steuert.

8. Gerät nach Anspruch 7, bei dem die Öffnungseinrichtung eine erste Öffnung (27a), die es ermöglicht, daß eine konstante Fläche des ersten Lichtempfangselements (28a) von der Lichtemissionseinrichtung (26) beleuchtet wird, und eine zweite Öffnung (27b) aufweist, die eine Fläche des zweiten Elements (28b) abhängig von der Betriebsposition des Verbundmagnetkopfs beleuchtet.

9. Gerät nach Anspruch 1, bei dem drei oder mehr voneinander beabstandete Lichtempfangselemente (Da_1 - Da_5, Db_1 - Db_6) angrenzend an eine Kante des Bands vorhanden sind, wobei die Anordnung dergestalt ist, daß die Ausgangssignale ausgewählter Lichtempfangselemente in jeder der Betriebspositionen vorgegebene Beziehungen einhalten.

10. Gerät nach Anspruch 9, bei dem das Ausgangssignal eines ausgewählten Lichtempfangselements (Da_1 - Da_5, Db_1 - Db_6) für jede Betriebsposition der Summe der Ausgangssignalen zweier anderer ausgewählter Lichtempfangselemente (Da_1 - Da_5, Db_1 - Db_5) gleich ist.

11. Gerät nach Anspruch 9 oder Anspruch 10, bei dem die Lichtempfangselemente am Verbundmagnetkopf angebracht sind und mit diesem verstellbar sind.

12. Gerät nach Anspruch 11, bei dem die Lichtempfangselemente im Betrieb um verschiedene Ausmaße gegenüber einer Kante des Bands versetzt sind.

13. Gerät nach Anspruch 12, b i dem die Schrittweit D_i zwischen d n Enden benachbarter Lichtempfangselement Da_i und Da_{i+1} in Quer(Y)-Richtung des Bands wi f lgt festg l gt ist:

$$d_i = d, \text{ wenn } i \leq 2 \text{ gilt}$$

und

$d_i = (i - 2) \cdot d$, w nn $3 \leqq i \leqq n - 1$ gilt wob i d die Schrittweit der Spur n auf d m Magnetband ist und n die Anzahl von Lichtempfangselementen ist.

14. Gerät nach einem der Ansprüche 9 bis 12, bei dem die Lichtempfangselemente in Längsrichtung (X) des Bands konstante Breite aufweisen.

15. Gerät nach Anspruch 9 oder Anspruch 10, bei dem das optische System eine Schlitzplatte (31) aufweist, die am Verbundmagnetkopf angebracht ist und mit diesem verstellbar ist und die zwischen der Lichtemissionseinrichtung (26) und den Lichtempfangselementen (Db_1 - Db_5) verstellbar ist und eine Öffnungseinrichtung (A_1 - A_5) aufweist, die es ermöglicht, daß Licht selektiv von der Lichtemissionseinrichtung (26) zur Ausgewählten der Lichtempfangselemente (Db_1 - Db_5, 32) mit einem Muster durchläuft, das von der Betriebsposition des Verbundmagnetkopfs abhängt.

16. Gerät nach Anspruch 15, bei dem die Öffnungseinrichtung (A_1 - A_5) mehrere Schlitze (A_1 - A_5) aufweist, die jeweils so ausgebildet sind, daß sie es erlauben, daß in Ausgewählten der Betriebspositionen des Verbundmagnetkopfs Licht von der Lichtemissionseinrichtung (26) zu einem jeweiligen Lichtempfangselement (Db_1 - Db_5) durchtritt.

17. Gerät nach Anspruch 16, bei dem die Schrittweite di zwischen den Enden benachbarter Schlitze A_i und A_{i+1} in der Schlitzplatte (31) in Querrichtung (Y) des Magnetbands wie folgt festgelegt ist:

$d_i = d$, wenn $i \leqq 2$ gilt

und

$d_i = (i - 2) \cdot d$, wenn $3 \leqq i \leqq n - 1$ gilt

wobei d die Schrittweite der Spuren auf dem Magnetband ist und n die Anzahl von Lichtempfangselementen ist.

18. Gerät nach einem der Ansprüche 15 bis 17, bei dem die Schlitze (A_1 - A_5) alle konstante Breite (f) in Längs(X)- Richtung des Bands aufweisen.

19. Gerät nach Anspruch 1, bei dem mehrere Lichtempfangselemente (Da_1 - Da_6, Db_1 - Db_6; Di_1 - Di_6, Dj_1 - Dj_6; Db_1 - Db_3, Da_1 - Da_3) angrenzend an jede Kante des Magnetbands vorhanden sind.

20. Gerät nach Anspruch 19, bei dem die Anzahl von Lichtempfangselementen angrenzend an jede Kant des Bands der Anzahl von Betriebspositionen entspricht.

21. Gerät nach Anspruch 20 oder Anspruch 21, bei d m Paare von Lichtempfangselem nt n (Da_1 - Da_6, Db_1 - Db_6; Di_1 - Di_6, Dj_1 - Dj_6; Db_1 - Db_3, Da_1 - Da_3) so angeordn t sind, daß in El m nt jedes Paar angrenzend an jede Seite des Magnetbands angeordnet ist, wobei die Anordnung ferner dergestalt ist, daß die Ausgangssignale jedes Paar von Lichtempfangselementen einer vorgegebenen Beziehung genügen, wenn sich der Verbundmagnetkopf in einer jeweiligen der Betriebspositionen befindet.

22. Gerät nach Anspruch 21, bei dem die vorgegebene Beziehung dergestalt ist, daß die Ausgangssignale der Lichtempfangselemente eines Paars Lichtempfangselemente gleich sind.

23. Gerät nach einem der Ansprüche 21 oder 22, bei dem die Lichtempfangselemente am Verbundmagnetkopf angebracht sind und mit diesem verstellbar sind, wobei die Lichtempfangselemente so positioniert sind, daß in jeder jeweiligen Betriebsposition die Lichtempfangselemente jeweiliger Paare von Lichtempfangselementen im wesentlichen mit den jeweiligen Kanten des Magnetbands ausgerichtet sind.

24. Gerät nach Anspruch 21 oder Anspruch 22, bei dem das optische System eine Schlitzplatte (37) aufweist, die am Verbundmagnetkopf angebracht ist und zwischen der Lichtemissionseinrichtung (43) und den Lichtempfangselementen (Di_1 - Di_6, Dj_1 - Dj_6) verstellbar ist, mit Öffnungseinrichtungen (Si_1 - Si_6, Sj_1 - Sj_6), die es ermöglichen, daß Licht in einer jeweiligen Betriebsposition zu jeweiligen Paaren von Lichtemissionselementen hindurchtritt.

25. Gerät nach Anspruch 24, bei dem die Lichtempfangselemente entlang der Kanten des Magnetbands angeordnet sind und die Öffnungseinrichtung mehrere Öffnungen (Si_1 - Si_6, Sj_1 - Sj_6) aufweist, die es ermöglichen, daß Licht in jeder jeweiligen Betriebsposition zu einem jeweiligen Paar von Lichtempfangselementen hindurchtreten kann.

26. Gerät nach einem der Ansprüche 1 und 23 bis 25, bei dem die Lichtemissionseinrichtung Licht über beide Kanten des Bands strahlt.

27. Gerät nach einem der vorstehenden Ansprüche, bei dem die Lichtempfangseinrichtungen so ange rdnet sind, daß die Ausgangssignale derselben eine vorgegeben B zi hung einhalt n, die di Funkti n d r R gelungseinrichtung bestimmt, wenn sich der Verbundmagnetkopf in einer j w iligen B tri bsposition befindet.

28. G rät nach inem der vorstehend n Ansprüch , mit iner Kopfb tätigungseinrichtung, di den Kombinationskopf in Br itenrichtung des Bands v rstellen kann.

29. Gerät nach einem der vorstehenden Ansprüche, bei dem der Verbundmagnetkopf zwischen den freien Enden zweier paralleler Blattfedern (57a, 57b) gehalten wird.

30. Gerät nach einem der vorstehenden Ansprüche, bei dem die Steuerungseinrichtung einen Schwingspule-Linearmotor (59) zum Einstellen und Beibehalten des Verbundkopfs in einer Ausgewählten der Betriebspositionen aufweist.

31. Gerät nach Anspruch 30, bei dem der Schwingspule-Linearmotor einen Magnetkreis aufweist, der in der Richtung des Verbundmagnetkopfs und der Richtung des Magnetbands geschlossen ist.

32. Gerät nach Anspruch 30 oder Anspruch 31 in Abhängigkeit von Anspruch 29, ferner mit einer Halteeinrichtung (53), die zwischen den freien Enden der parallelen Blattfedern (57a, 57b) angeordnet ist und den Verbundmagnetkopf trägt und auf eine Verstellung der Spule des Schwingspule-Linearmotors anspricht, um die Betriebsposition des Verbundmagnetkopfs einzustellen und aufrecht zu erhalten.

33. Gerät nach Anspruch 32, bei dem die Schwingspule auf solche Weise mit der Halteeinrichtung verbunden ist, daß die Kraft von der Schwingspule in der Nähe der Schwerkraft der Halteeinrichtung wirkt.

34. Magnetisches Aufzeichnungs-/Wiedergabesystem vom Mäandertyp mit einem Gerät nach einem der vorstehenden Ansprüche.

Revendications

1. Appareil d'enregistrement / reproduction magnétique comportant une tête magnétique composite (13; 21; 51; 67) ayant un certain nombre de têtes d'enregistrement reproduction (W_{1-8}, R_{1-8}; W_{1-16}, R_{1-16}) qui est inférieur au nombre de pistes (24; 66; T_{1-48}) qui sont prévues sur la bande magnétique (11; 23; 52; 65) parallèlement les unes aux autres et dans la direction (X) de défilement de la band , ladite tête composite étant apt à être déplacée par rapp rt à la band magnétique dans la directi n (Y) de la largeur de la bande jusqu'à un certain n mbre d positions d fonctionnement à chacune d squelles lesdites têtes sont aligné s avec un ensembl resp ctif de pist s souhaité s parmi lesdites pist s, caractérisé par la prés nce de moy ns d commande pour régler et maintenir ladite tête composite à une position sélectionnée parmi lesdites positions, lesdits moyens de commande comprenant un système optique (26, 22; 26, 27, 22; 26, 29; 26, 31, 32; 36, 33; 43, 37, 38; 63, 68) ayant des moyens émetteurs de lumière (26; 36; 43; 63) et des moyens récepteurs de lumière à éléments multiples (25a, 25b; 28a, 28b; 30; Db_{1-5}; 34, 35; 39, 40; 69, 70) disposés sur des côtés opposés de la bande et agencés de manière à transmettre de la lumière pour qu'elle franchisse au moins un bord de la bande de telle sorte que la configuration de lumière transmise auxdits moyens récepteurs de lumière à éléments multiples dépende de ladite position de fonctionnement de la tête composite par rapport à la bande.

2. Appareil selon la revendication 1, dans lequel les moyens récepteurs de lumière comprennent des premier (25a; 28a) et second (25b; 28b) éléments récepteurs de lumière, leur agencement étant tel que la sortie du second élément récepteur de lumière soit un multiple de la sortie du premier élément récepteur de lumière en fonction de la position de fonctionnement de la tête magnétique composite.

3. Appareil selon la revendication 2, dans lequel, pour chaque position de fonctionnement de la tête magnétique composite, une superficie constante dudit premier élément récepteur de lumière est exposée à la lumière en provenance desdits moyens émetteurs de lumière, tandis que la superficie du second élément récepteur de lumière exposée à la lumière en provenance des moyens émetteurs de lumière varie en fonction de la position de fonctionnement de la tête magnétique composite.

4. Appareil selon la revendication 3, dans lequel le premier élément récepteur de lumière est positionné de telle sorte que la bande ne bloque pas la lumière en provenance des moyens émetteurs de lumière, tandis que le second élément est positionné de telle sorte qu'un bord de la bande empêche la lumière de parvenir au second élément en fonction de la position de fonctionnement de la tête magnétique composite.

5. Appareil selon la revendication 4, dans l qu l la quantité de lumière r çu par l second élément réc pteur d lumière pour chaqu position d fonctionnement la tête magnétiqu composite est

un multipl entier de la lumière r çue par le premier élém nt, le multipl nti r correspondant à la position d fonctionn m nt resp ctiv .

6. Appareil selon l'une quelconque des revendications précédentes, dans lequel les moyens récepteurs de lumière (25a, 25b) sont montés sur la tête magnétique composite, avec laquelle ils sont aptes à se déplacer.

7. Appareil selon l'une quelconque des revendications des revendications 1 à 5, dans lequel le système optique comprend une plaque à fentes (27) montée sur la tête magnétique composite est apte à se déplacer avec cette dernière, la plaque à fentes étant apte à se déplacer entre les moyens émetteurs de lumière (26) et les moyens récepteurs de lumière (28a, 28b) et comportant des moyens formant ouverture (27a, 27b) qui commandent la configuration de lumière transmise aux premier et second éléments récepteurs de lumière en fonction de la position de fonctionnement de la tête magnétique composite.

8. Appareil selon la revendication 7, dans lequel les moyens formant ouverture comportent une première ouverture (27a) permettant l'illumination par lesdits moyens émetteurs de lumière (26) d'une superficie constante dudit premier élément récepteur de lumière (28a), ainsi qu'une seconde ouverture illuminant une superficie du second élément (28b) en fonction de la position de fonctionnement de la tête magnétique composite.

9. Appareil selon la revendication 1, dans lequel trois, ou plus de trois, éléments récepteurs de lumière (Da_1 à Da_5, Db_1 à Db_5)), espacés les uns des autres, sont prévus à proximité d'un bord de la bande, l'agencement étant tel que des sorties d'éléments sélectionnés parmi lesdits éléments récepteurs de lumière présentent des relations prédéterminées pour chacune des positions de fonctionnement.

10. Appareil selon la revendication 9, dans lequel, pour chaque position de fonctionnement, la sortie d'un élément récepteur de lumière (Da_1 à Da_5, Db_1 à Db_5) sélectionné est égale à la somme des sorties de deux autres éléments récepteurs de lumière (Da_1 à Da_5, Db_1 à Db_5) sélectionnés.

11. Appareil selon la revendication 9 ou la revendication 10, dans lequel les éléments récepteurs de lumière sont montés sur la tête magnétiqu composite et apt s à se déplacer avec celle-ci.

12. Appareil selon la r vendicati n 11, dans lequel les éléments récepteurs de lumièr sont déplacés, n fonctionnement, de valeurs différentes, par rapport à un bord de la band .

13. Appareil selon la revendication 12, dans lequel le pas d_i entre les extrémités des éléments récepteurs de lumière adjacents Da_i et Da_{i+1}, dans la direction latérale (Y) de la bande, est déterminé de la manière suivante:

$$d_i = d \text{ lorsque } i \leqq 2$$

et

$$d_i = (i - 2) d \text{ lorsque } 3 \leqq i \leqq n - 1$$

où d est le pas des pistes sur la bande magnétique et n est le nombre d'éléments récepteurs de lumière.

14. Appareil selon l'une quelconque des revendications 9 à 12, dans lequel les éléments récepteurs de lumière sont de largeur constante dans la direction longitudinale (X) de ladite bande.

15. Appareil selon la revendication 9 ou la revendication 10, dans lequel le système optique comprend une plaque à fentes (31) montée sur la tête magnétique composite et apte à se déplacer avec cette dernière, la plaque à fentes (31) étant apte à se déplacer entre les moyens émetteurs de lumière (26) et les éléments récepteurs de lumière (Db_1 à Db_5) et comportant des moyens formant ouverture (A_1 à A_5) qui permettent à la lumière, de façon sélective, de passer, des moyens émetteurs de lumière (26) à des éléments sélectionnés parmi les éléments récepteurs de lumière (Db_1 à Db_5, 32) suivant une configuration dépendant de la position de fonctionnement de la tête magnétique composite.

16. Appareil selon la revendication 15, dans lequel les moyens formant ouverture (A_1 à A_5) comportent une multiplicité de fentes (A_1 à A_5), chacune desdites fentes étant agencée de manière à laisser passer de la lumière depuis les moyens émetteurs de lumière (26) jusqu'à un élément récepteur de lumière respectif (Db_1 à Db_5) pour des positions sélectionnées parmi les positions de fonctionnement de la tête magnétique composite.

17. Appareil selon la revendication 16, dans lequel le pas d_i entre les extrémités des fentes A_i et A_{i+1} adjacentes de la plaque à fentes (31) dans la direction latérale (Y) de la bande magnétique est déterminé de la manière suivante:

$$d_i = d \text{ lorsque } i \leqq 2$$

$$d_i = (i - 2d) \text{ lorsque } 3 \leqq i \leqq n - 1$$

où d est l pas des pistes sur la band magnétique t n est le nombre d fentes de la plaqu à fentes.

18. Appareil selon l'une quelconque d s r vendica-

tions 15 à 17, dans l quel les f ntes (A_1 à A_5) sont tout s d'un largeur constant (f) dans la dir c- tion longitudinal (X) d ladit bande.

19. Appareil selon la revendication 1, dans lequel une multiplicité d'éléments récepteurs de lumière (Da_1 à Da_6, Db_1 à Db_6; Di_1 à Di_6, Dj_1 à Dj_6; Db_1 à Db_3, Da_1 à Da_3) sont prévus à proximité de chaque bord de la bande magnétique.

20. Appareil selon la revendication 19, dans lequel le nombre d'éléments récepteurs de lumière adjacents à chaque bord de la bande est égal de préférence au nombre de positions de fonctionnement.

21. Appareil selon la revendication 20 ou la revendication 21, dans lequel des paires d'éléments récepteurs de lumière (Da_1 à Da_6, Db_1 à Db_6; Di_1 à Di_6, Dj_1 à Dj_6; Db_1 à Db_3, Da_1 à Da_3) sont disposées de telle sorte qu'un élément de chaque paire soit adjacent à chaque bord de la bande magnétique, l'agencement étant tel que les sorties de chaque paire d'éléments récepteurs de lumière se conforment à une relation prédéterminée lorsque la tête magnétique composite se trouve à une position respective parmi les positions de fonctionnement.

22. Appareil selon la revendication 21, dans lequel la relation prédéterminée exige que les sorties des éléments récepteurs de lumière d'une paire d'éléments récepteurs de lumière soient équilibrés.

23. Appareil selon la revendication 21 ou 22, dans lequel les moyens récepteurs de lumière sont montés sur ladite tête magnétique composite et sont aptes à se déplacer avec cette dernière, les éléments récepteurs de lumière étant positionnés de sorte que les éléments récepteurs de lumière de paires respectives d'éléments récepteurs de lumière soient sensiblement alignés avec des bords respectifs de la bande magnétique pour chaque position de fonctionnement respective.

24. Appareil selon la revendication 21 ou la revendication 22, dans lequel le système optique comprend une plaque à fentes (37) montée sur la tête magnétique composite et apte à se déplacer entre les moyens émetteurs de lumière (43) et les éléments récepteurs de lumière (Di_1 à Di_6, Dj_1 à j_6) et comportant des moyens formant ouverture (Si_1 à Si_6, Sj_1 à Sj_6) qui permettent à la lumière d parvenir jusqu'à des paires respectives d'éléments émetteurs de lumière pour chaque position d fonctionn ment r spectiv .

25. Appareil selon la revendication 24, dans lequel les éléments récepteurs de lumièr sont disposés le long des bords de ladit bande magnétiqu t l s moyens formant ouv rture s composent d'une multiplicité d'ouvertures (Si_1 à Si_6, Sj_1 à Sj_6)qui permettent à la lumière de parvenir jusqu'à une paire respective d'éléments récepteurs de lumière pour chaque position de fonctionnement respective.

26. Appareil selon l'une quelconque des revendications 1 et 23 à 25, dans lequel lesdits moyens émetteurs de lumière émettent de la lumière de manière à ce qu'elle franchisse les deux bords de la bande.

27. Appareil selon l'une quelconque des revendications précédentes, dans lequel lesdits moyens récepteurs de lumière sont agencés de telle sorte que des sorties en provenance desdits moyens récepteurs de lumière présentent des relations prédéterminées auxquelles sont soumis lesdits moyens de commande lorsque ladite tête magnétique composite se trouve à chaque position de fonctionnement.

28. Appareil selon l'une quelconque des revendications précédentes comprenant des moyens de commande de tête aptes à déplacer ladite tête composite dans la direction de la largeur de ladite bande.

29. Appareil selon l'une quelconque des revendications précédentes, dans lequel ladite tête magnétique composite est supportée entre les extrémités libres de deux ressorts à lame parallèles (57a, 57b).

30. Appareil selon l'une quelconque des revendications précédentes, dans lequel les moyens de commande comprennent un moteur linéaire (59) du type à bobine mobile pour régler et maintenir la tête composite à une position sélectionnée parmi lesdites positions de fonctionnement.

31. Appareil selon la revendication 10, dans lequel le moteur linéaire du type à bobine mobile comporte un circuit magnétique qui est fermé dans la direction de la tête magnétique composite et dans la direction de la bande magnétique.

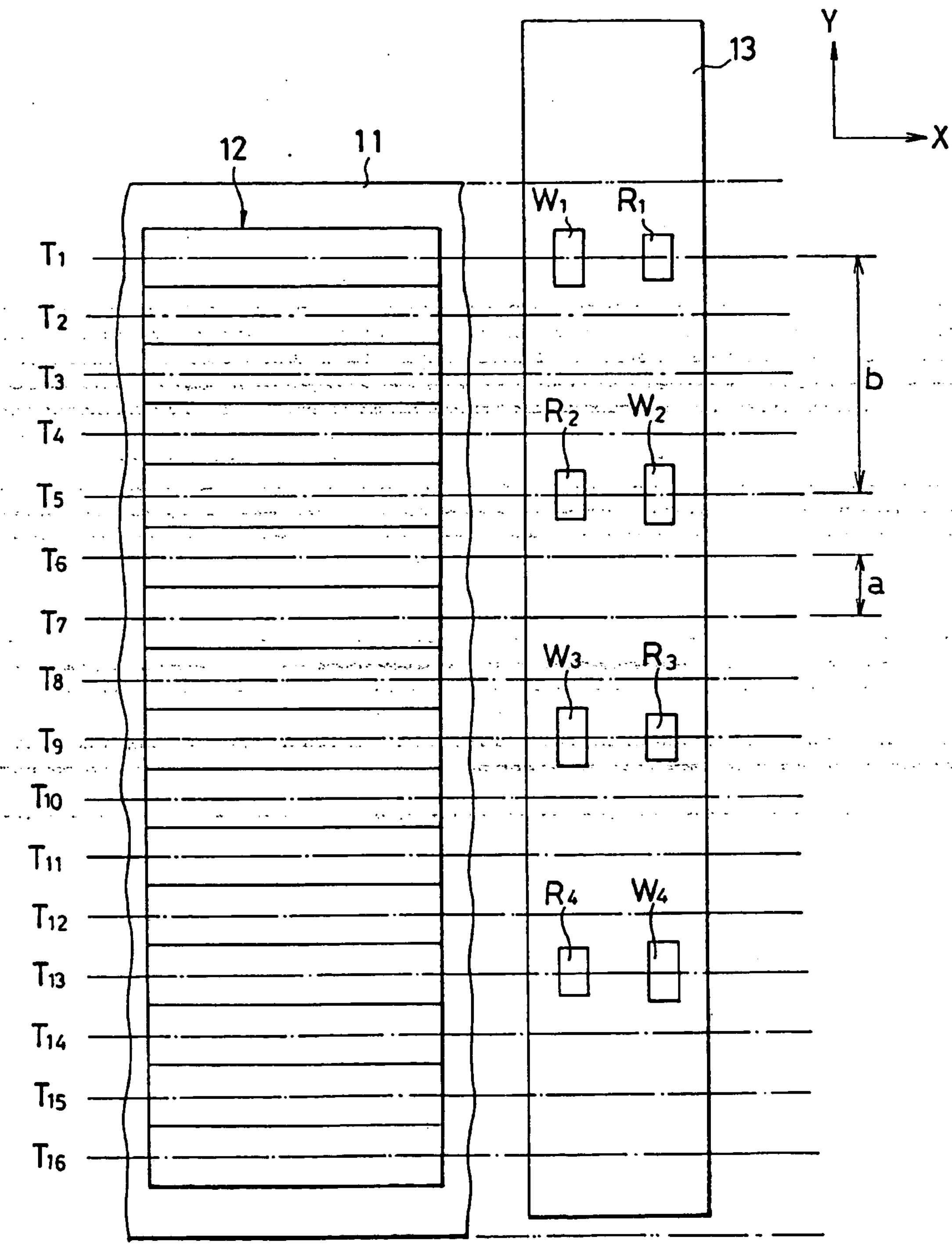
32. Appareil selon la revendication 30 ou la revendication 31, lorsque celles-ci dépendent de la rev ndication 29, comprenant en outre des moyens de support (53) qui sont disposés entre les extrémités libres des ressorts à lame parallèles (57a, 57b), les m yens d support supportant la tête magnétique composit et étant sensibl s au

mouvement d la bobine du mot ur linéair du typ bobine mobil pour régler t maint nir la position de fonctionnement d la t^te magnétiqu composite.

33. Appareil selon la revendication 32, dans lequel la bobine mobile est reliée aux moyens de support de manière à ce que la force en provenance de la bobine mobile soit appliquée au voisinage du centre de gravité des moyens de support.

34. Système d' enregistrement/reproduction magnétique du type à serpentin incorporant l'appareil selon l'une quelconque des revendications précédentes.

Fig. 1



13
Y
X
12
11
W1
R1
T1
T2
T3
T4
T5
T6
T7
T8
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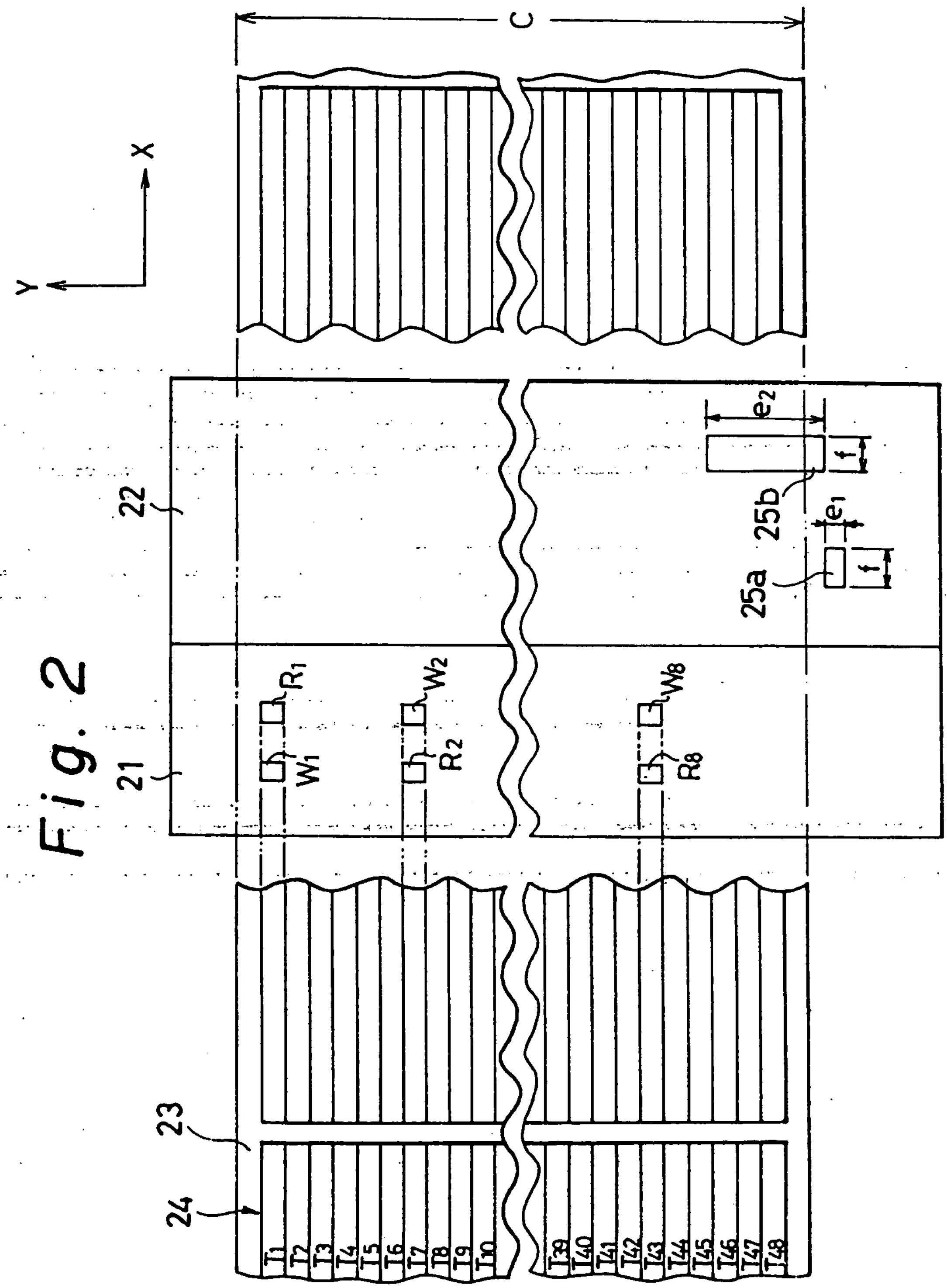
T10
T11
T12
T13
T14
T15
T16
R2
W2
W3
R3
R4
W4
b
a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X
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23
24
R1
W1
W2
R2
W8
R8
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e1
f
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25a
T1
T2
T3
T4
T5
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T10
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T48

Fig. 2

Fig. 3a

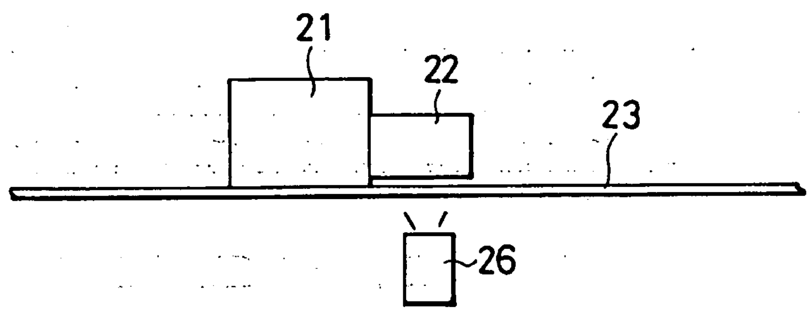


Fig. 3b

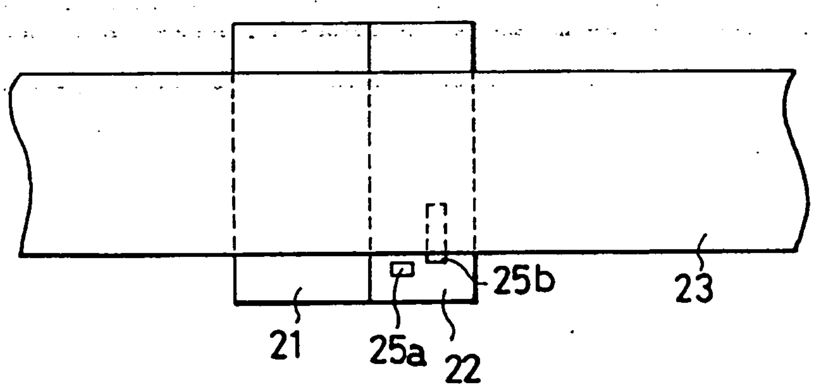
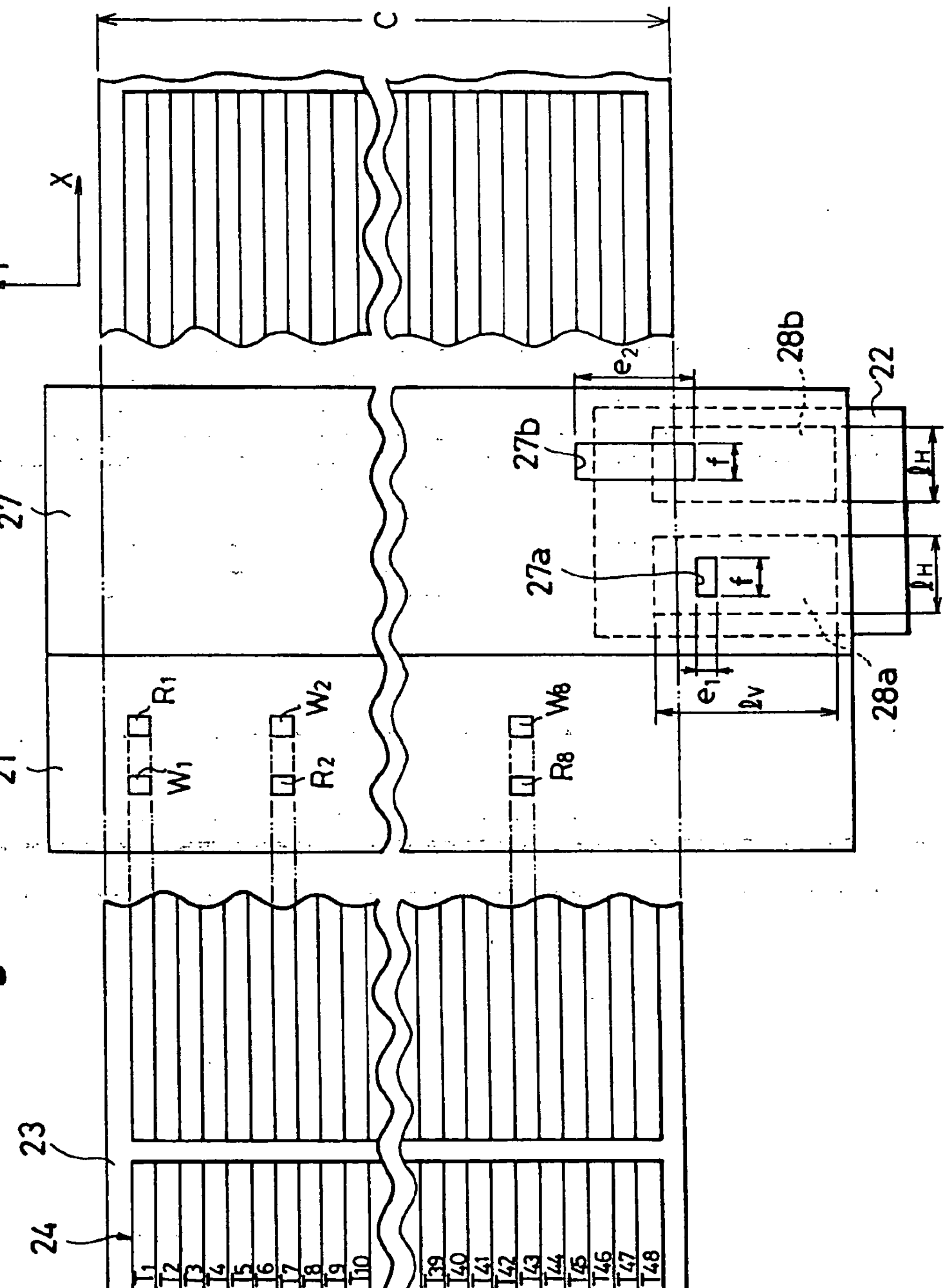


Fig. 4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X
Y
27
21
23
24
R1
W1
W2
R2
W8
R8
27a
27b
28a
28b
22
e1
e2
f
ℓV
ℓH
T1
T2
T3
T4
T5
T6
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T48

Fig.5a

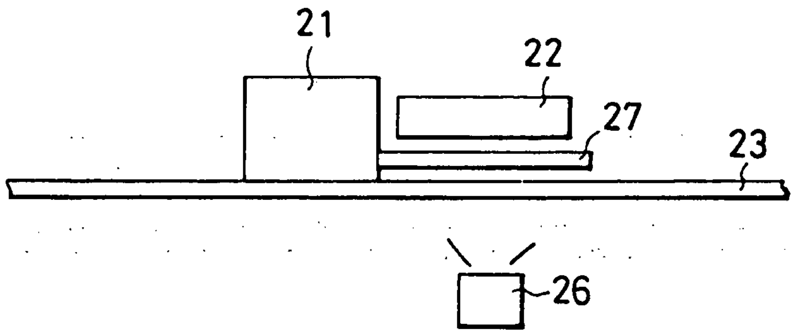


Fig.5b

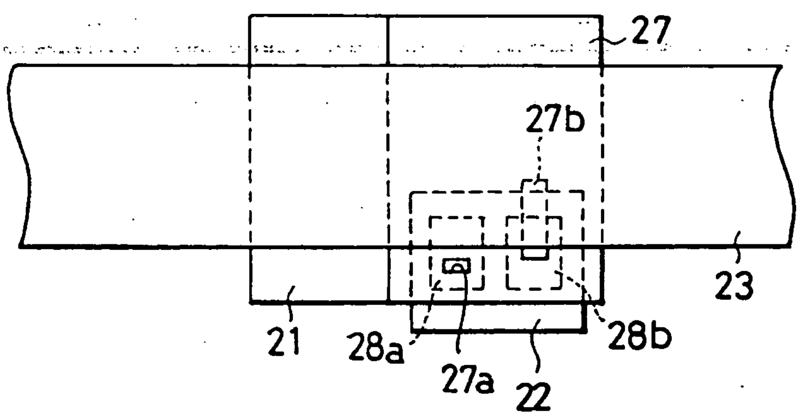
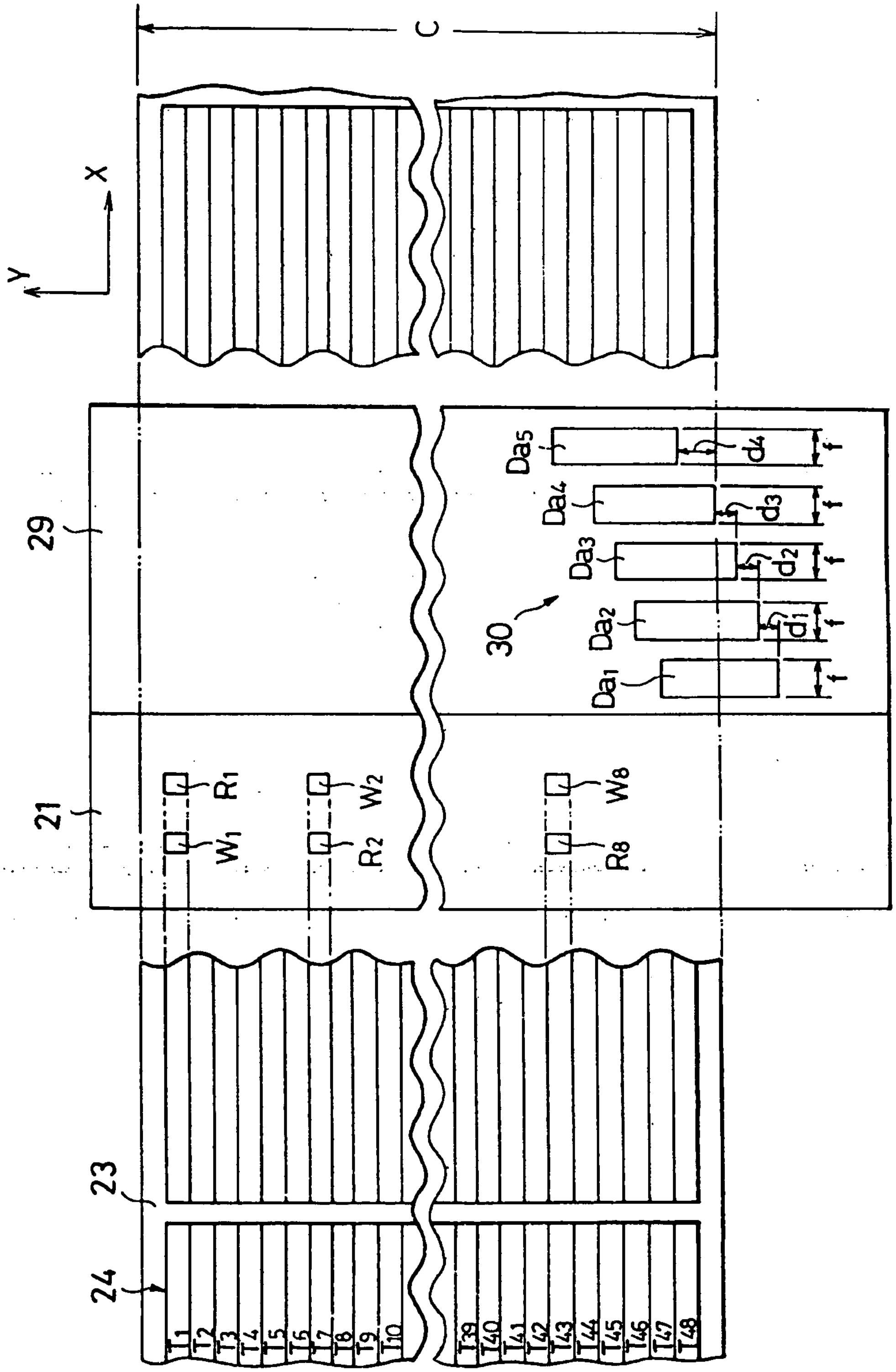


Fig. 6


C
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30
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R1
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W2
R2
W8
R8
Da1
Da2
Da3
Da4
Da5
d1
d2
d3
d4
f
T1
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Fig. 7a

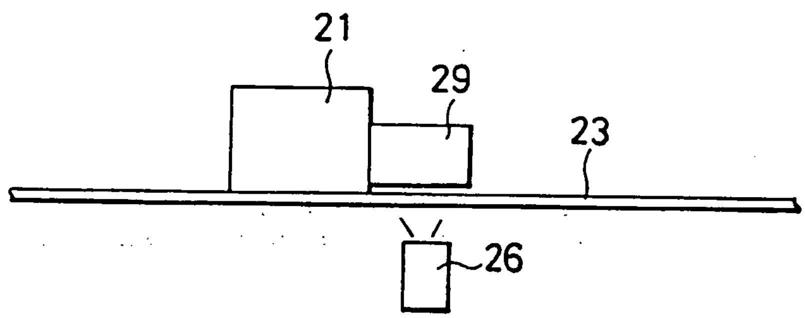


Fig. 7b

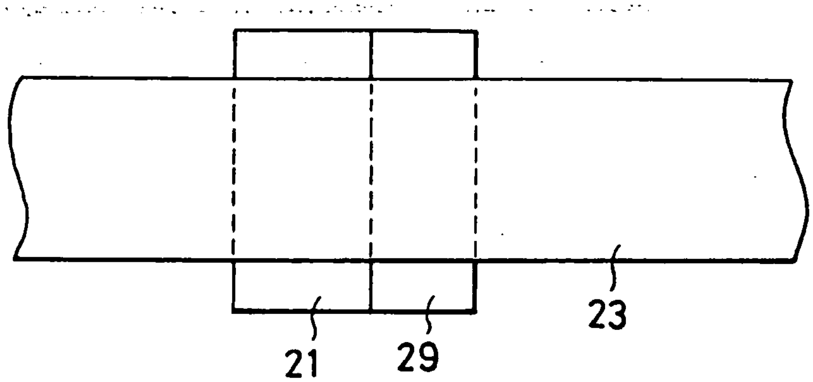
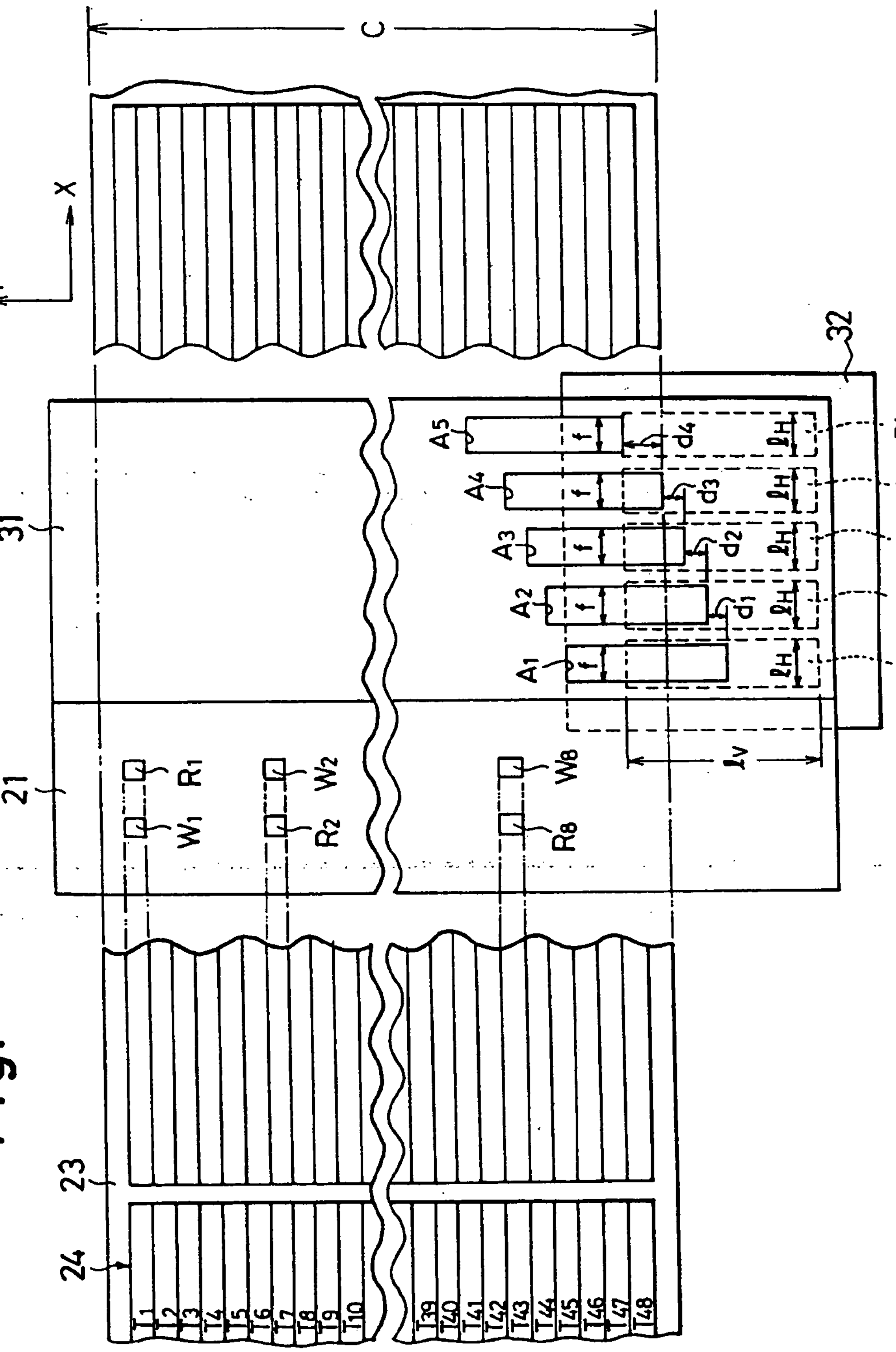


Fig. 8


C
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A2
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A4
A5
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d2
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d4
Db1
Db2
Db3
Db4
Db5
W1
R1
R2
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R8
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T1
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Fig. 9a

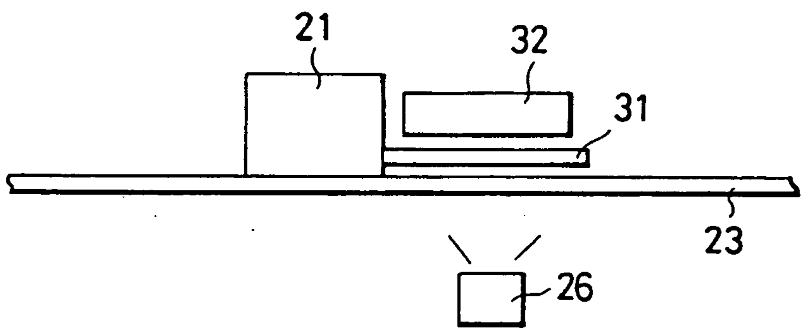


Fig. 9b

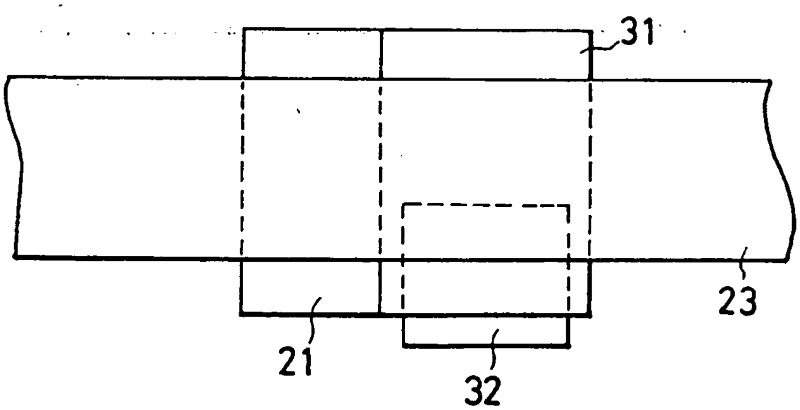
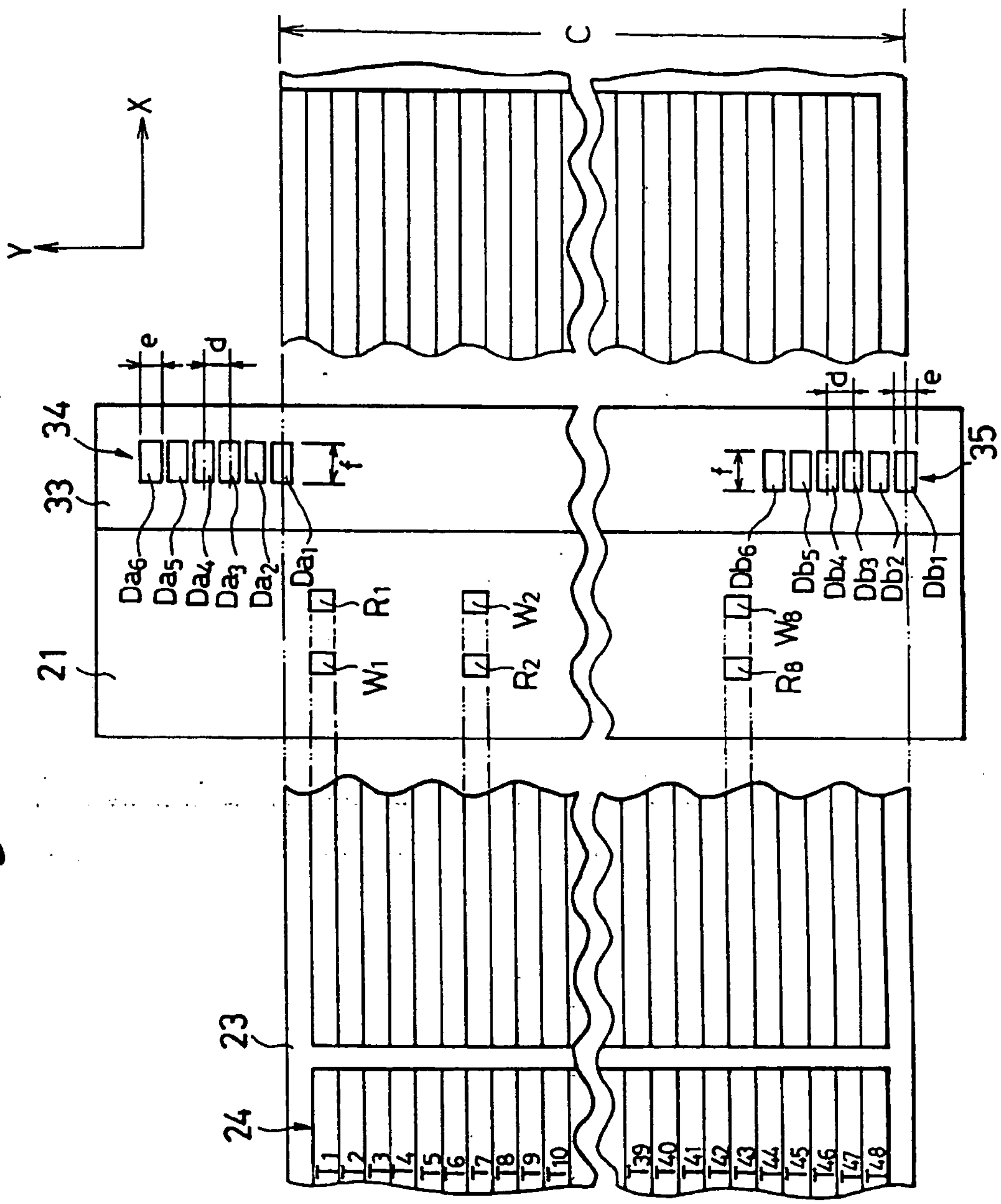


Fig. 10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Db1
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Db4
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Fig. 11a

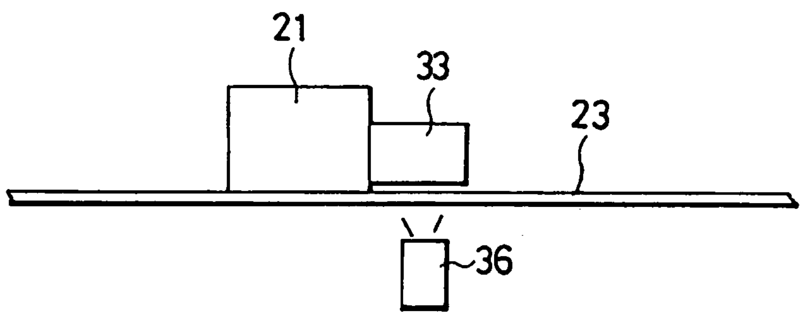

Fig. 11b

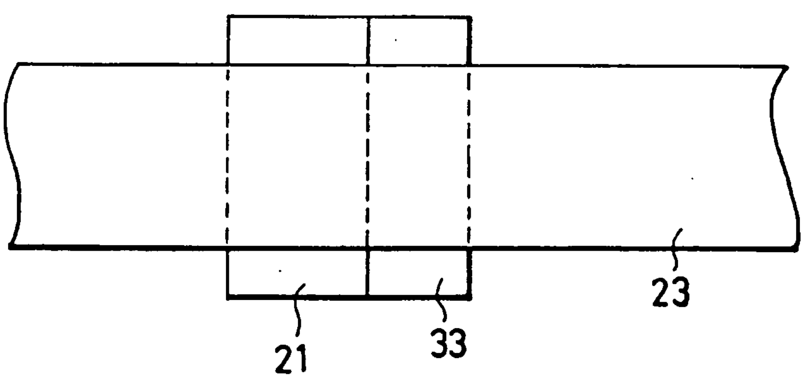

Fig. 12

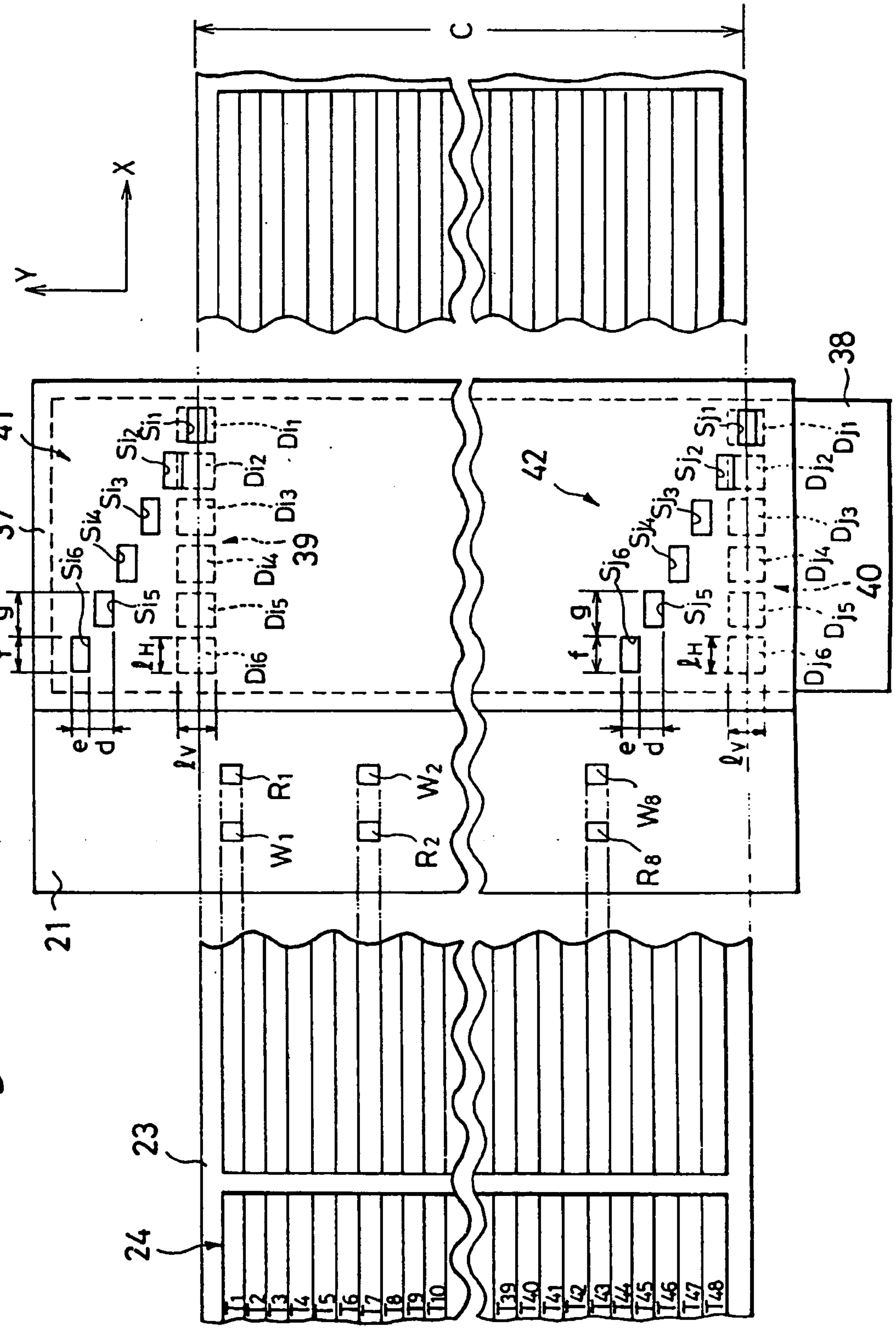
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Fig. 13a

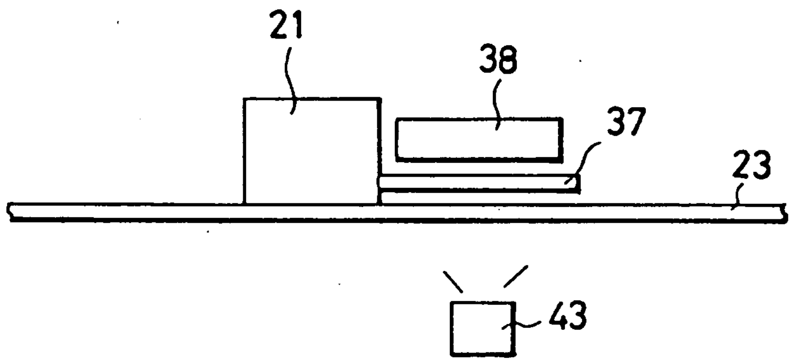


Fig. 13b

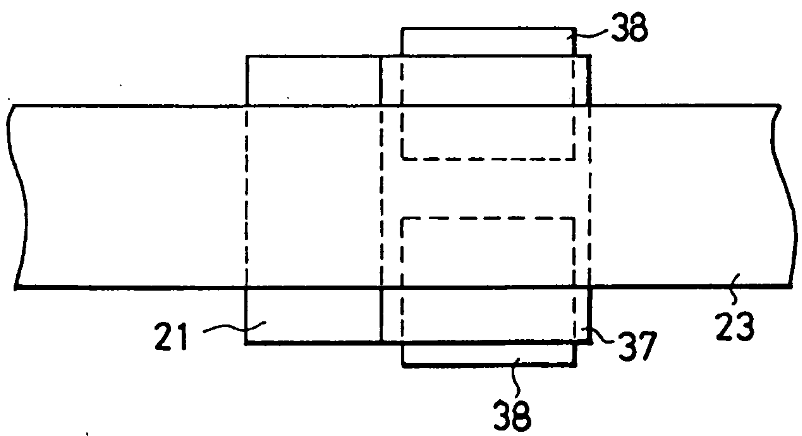
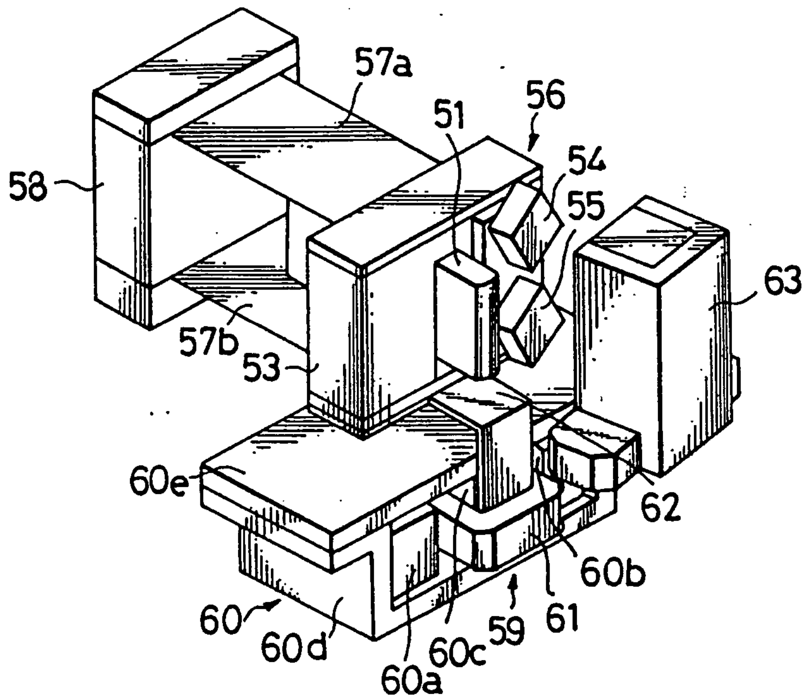


Fig. 14


57a
56
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60b
61
60
60d
60c
59
60a

Fig. 15

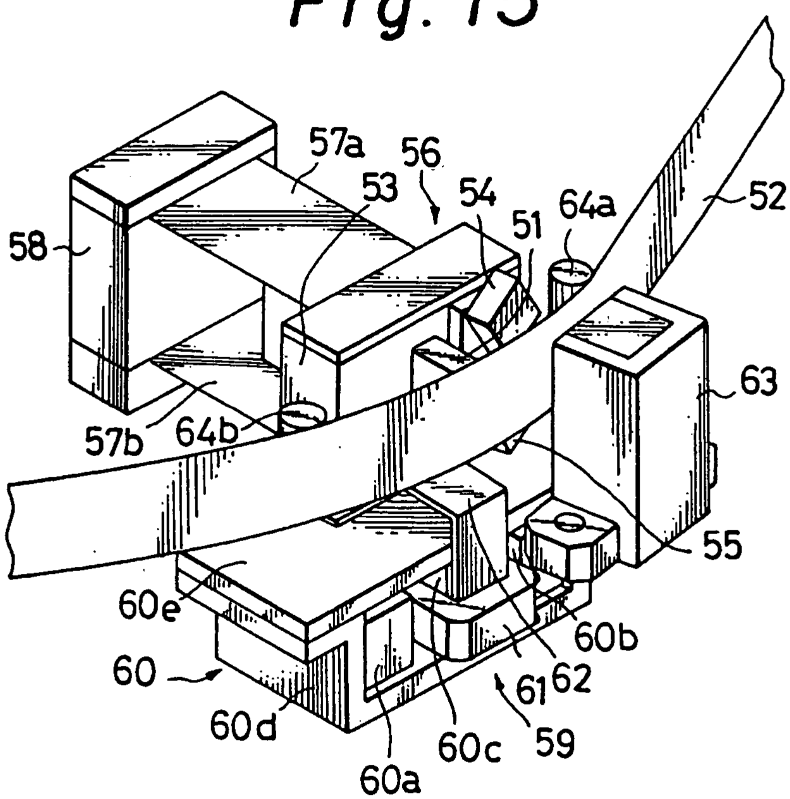
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Fig. 16

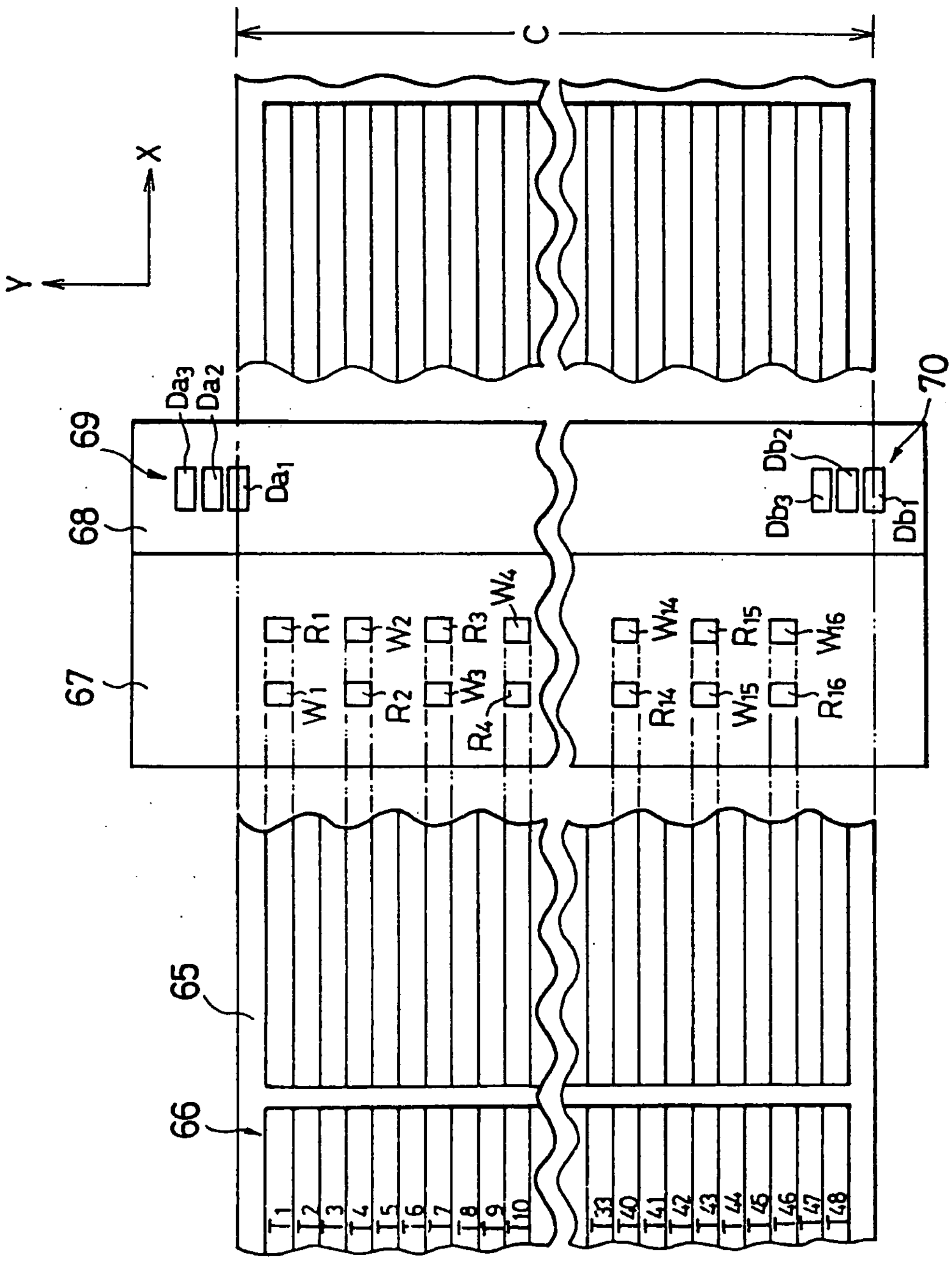
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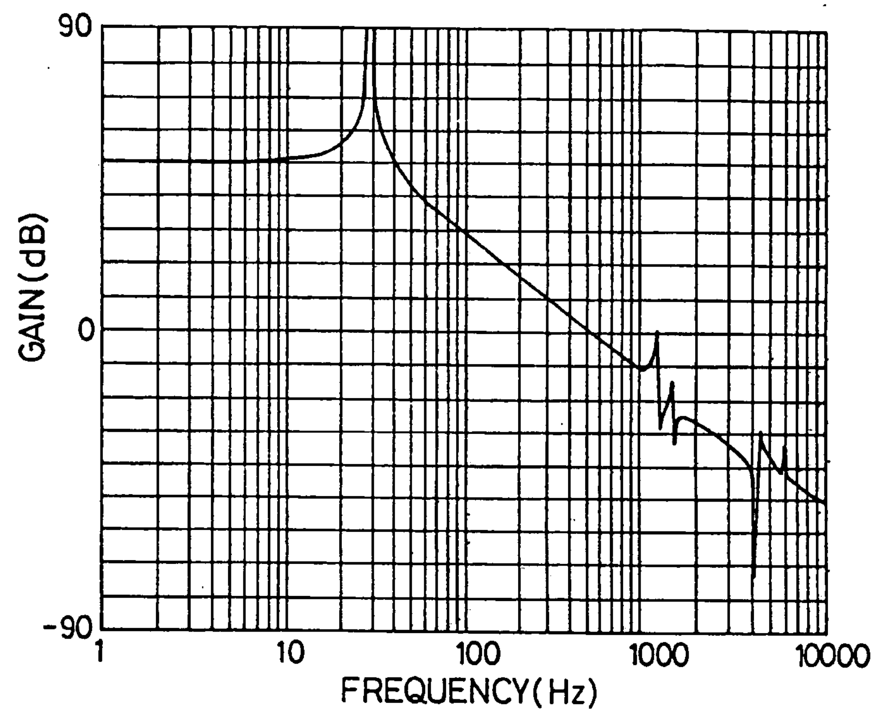
Fig. 17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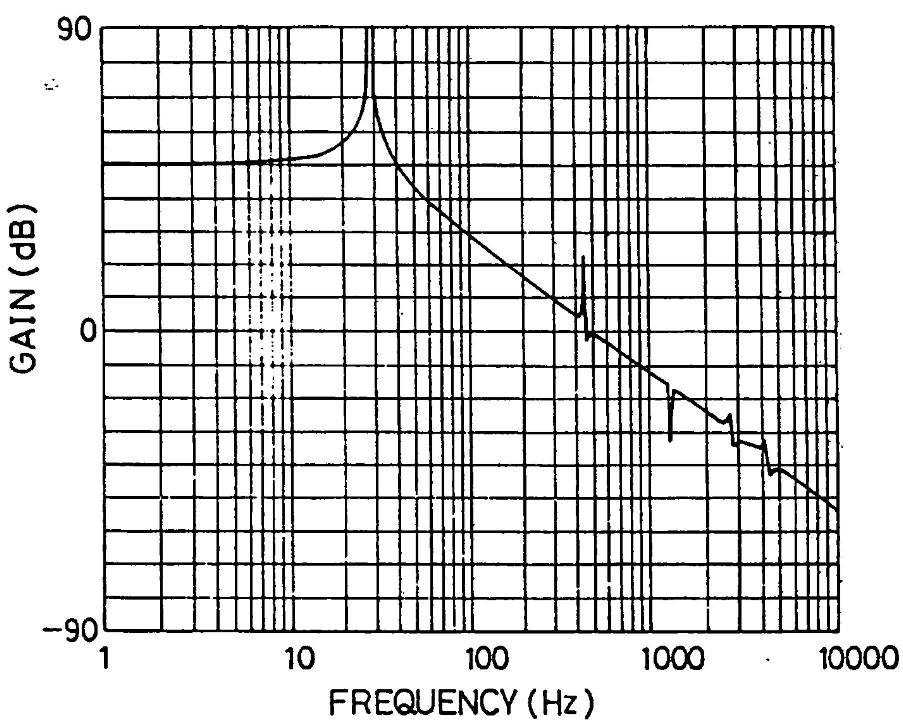
0
-90
GAIN (dB)
1
10
100
1000
10000
FREQUENCY (Hz)

Fig. 18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GAIN (dB)
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100
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FREQUENCY (Hz)